# SEASONAL TEMPERATURE RECONSTRUCTIONS ON THE NORTH ICELANDIC SHELF: EVIDENCE FROM STABLE ISOTOPE VALUES OF MARINE BIVALVES

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## PERMISSION TO USE

## ABSTRACT

Recent episodes of extreme weather and the drastic consequences they can have for ecosystems, societies, and economies, emphasize the need for a better understanding of Earth's climate. In order to gain a better understanding of modern and future climate, a more thorough knowledge of past climates at the highest resolution possible from different regions is necessary. To this end, a study of seasonal temperature variability in the waters off the northern coast of Iceland was undertaken. Twenty-six bivalves were selected from marine sediment cores recovered from the northern and northwestern coasts of Iceland. Bivalves were selected from intervals of climatic interest as determined from sedimentological characteristics. Shells were micromilled and the carbonate analysed for stable oxygen and carbon isotope values. Oxygen isotope values are driven principally by the temperature of the water from which the shell was precipitated. These data provide a time-series of discrete climate profiles of seasonal temperature variations from c. 360 cal yr BC to cal yr AD 1660, each recording 2 to 9 consecutive years of temperature variability. Several notable warm and cold periods were identified and characterized in terms of maximum and minimum temperatures. As this period overlaps the Viking Age (c. 790 to 1070) and the establishment of Norse colonies in Iceland and Greenland, the temperature record was compared with historical records and demonstrates the significant impact of variation in temperature seasonality on the establishment, development, and in some cases, collapse of societies in the North Atlantic.

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# CHAPTER 1.
# INTRODUCTION

## 1.1 Purpose of the Study

A more thorough understanding of present climate and the ability to better predict future climatic trends are crucial to global economies, societies, and infrastructure. This requires knowledge of the magnitude of natural climatic variability, the speed at which climate change occurs, climate forcing mechanisms, and the spatial extent of these mechanisms (e.g. Houghton et al., 1996). In order to separate natural forcing factors from anthropogenic forcing, it is critical to extend the climate record beyond the instrumental record, which is both spatially and temporally restricted (Jones et al., 2001). This can only be obtained through the use of palaeoclimatological proxies of past environments such as ice cores (e.g. Dansgaard et al., 1975), and tree-rings (e.g. Grudd et al., 2002). In particular, seasonal data is required in order to better characterize natural climatic variability (Barnett et al., 1999), and proxy data of oceanic temperature are needed to develop better models of ocean-atmosphere interaction (Barnett el al., 2001). This study aims to provide a seasonal record of water temperature from the climatically sensitive area of the north Iceland shelf.

## 1.2 Study Area

The North Atlantic region is the location of several major features that influence regional as well as global climate making it an important site for climate research. The North Atlantic is the site of deep-water formation that drives what is known variably as thermohaline circulation (THC) or meridional overturning circulation (MOC). This mechanism is responsible for the moderated climate experienced at high northern latitudes of the North Atlantic region, from the United States to Europe (Curry and Mauritzen, 2005). Warm tropical waters are carried along westerly currents such as the Gulf Stream northward into the North Atlantic Ocean, specifically the Greenland-Iceland-Norwegian (GIN) seas. Here the waters cool and sink below the less saline water of Arctic origin, forming North Atlantic Deep Water that flows south (Wunsch, 2002). A decrease in the intensity of this circulation, and perhaps even its temporary shutdown, has been hypothesized as the trigger of past cold periods including the Younger Dryas (Houghton et al., 2001) and the 8200-year cold event (Ellison et al., 2006).

The North Atlantic is also the site of two important pressure centres, the Iceland Low and the Azores High. The relative strengths and positions of these centres determine the intensity of westerly winds and the direction of storm tracks from the eastern United States to Europe (Visbeck et al., 2003). The pattern of variability in the Iceland Low and Azores High is known as the North

Atlantic Oscillation (NAO) and is one of the main drivers of climate variability in the Atlantic region, from the eastern United States to parts of central Europe and Asia, and from the Mediterranean to the Arctic Oceans (Hurrell et al., 2003).

Iceland is uniquely situated in the North Atlantic Ocean at the confluence of these major atmospheric and oceanic fronts of Arctic and Atlantic origin (Fig. 1.1), and as such is in a position to record changes in the intensity and location of these fronts. The continental shelves and fjords of the Iceland coast is a collection site of sediment that accumulates at a much faster rate than that of the open ocean, and therefore produces a sedimentological record of higher resolution that is available from most open ocean sites. Major international research projects of the last decade or more have focused on this important area of palaeoclimatology and have found that it records climatic variation since from at least the last glaciation of varying resolutions – millennial, centennial, and decadal. In order to assess the seasonal variation of climate, molluscs from these sediment cores were chosen and analysed to provide the highest resolution records of this area to date.

**1.3 Methodology**

Stable oxygen and carbon isotope values of biogenic carbonate have been used for over 50 years to determine palaeoenvironmental conditions (e.g. Urey, 1947). Mollusc shells have been widely to reconstruct a wide range of environmental variables in both ancient and modern settings, including the temperature, salinity, and oxygen isotope value ($\delta^{18}O$) of ambient water (e.g. Wefer and Berger, 1991; Klein et al., 1996; Wurster and Patterson, 2001), as well as timing of upwelling events (Jones et al., 1995), growth patterns, and ecology (Jones et al., 1983; Krantz et al., 1987). Recent technological advances in computer-controlled micromilling provide the capability for fine-scale incremental sampling of carbonate materials, yielding sub-annual, sub-seasonal, and even daily resolution of carbonate material (Wurster and Patterson, 2001). In this study, shells of marine bivalves are used to determine past temperature variability in the near-shore marine environment of the northwest Iceland shelf.

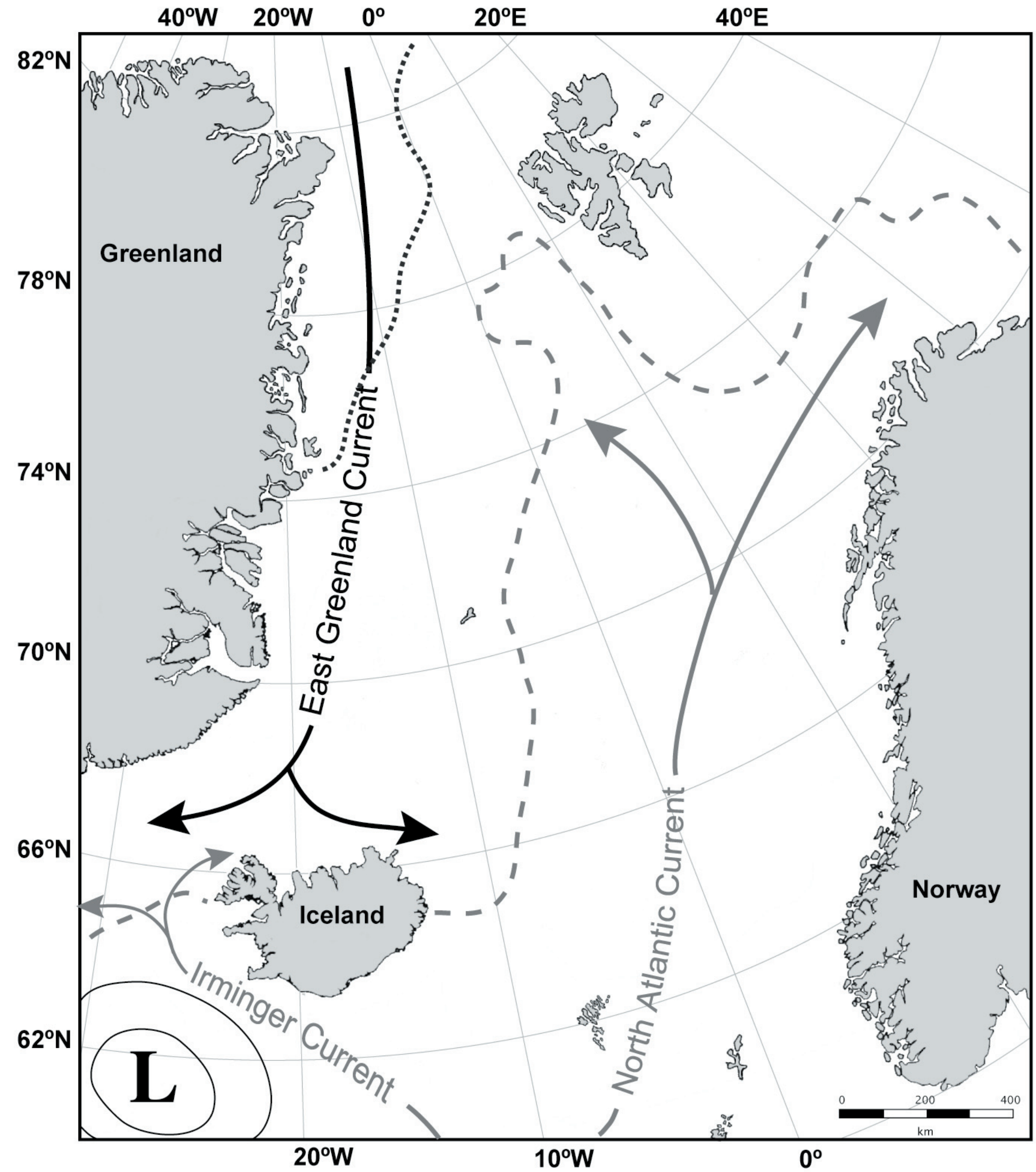


Fig. 1.1 Iceland and surrounding region. Black solid lines denote main surface currents of Arctic origin, gray solid lines denote main surface currents of Atlantic origin. Dotted line represents typical sea-ice limit in mild summer, dashed line represents typical sea-ice limit in severe winter. The approximate average position of the Icelandic Low is shown with an L. (Modified after Andrews et al., 2002 and Jennings et al., 2001).

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# CHAPTER 2.
# SEASONAL TEMPERATURE RECONSTRUCTIONS ON THE NORTH ICELANDIC SHELF


## 2.1 Abstract

A series of high-resolution (weekly to sub-weekly) temperature reconstructions is derived from $\delta^{18}O$ and $\delta^{13}C$ values of Holocene marine bivalve carbonate from the northwest Icelandic shelf. Twenty-six bivalves were extracted from four near-shore marine cores at discrete stratigraphic intervals that represent periods of climatic extremes. The intervals are dated from 360 cal yr BC to cal yr AD 1660 based on AMS radiocarbon dating of select shells and interpolation between the dates. One valve from each bivalve was micromilled to recover carbonate samples at a resolution that represents as few as 2 days. $\delta^{18}O$ values of the carbonate are primarily controlled by ambient water temperature, and thus record sub-seasonal temperature variation over the growth period of the bivalves, ranging from 2 to 9 years. $\delta^{13}C$ values were well correlated with $\delta^{18}O$ values in certain specimens, indicating that temperature was the dominant influence of $\delta^{13}C$ via uptake of metabolic carbon. In other specimens, $\delta^{13}C$ values were poorly correlated with $\delta^{18}O$ values, suggesting other carbon sources were more influential. In one species, *Thyasira flexuosa*, $\delta^{13}C$ values were lower (-3 to -8‰ VPDB, compared to +3 to -3‰ VPDB for all other species) suggesting the influence of symbiotic sulfur-oxidizing bacteria on the metabolic carbon input. Stratigraphic intervals were characterized in terms of maximum and minimum seasonal water temperatures, and variability of temperature extremes. Three notable cold intervals occur from 360 to 230 BC, at AD 410, and from AD 1380 to 1420. Two notable warm periods are apparent at 220 BC to AD 140 and AD 610 to 760. Comparison between mollusc-derived temperature data and historical documents from this period indicates the influence of climatic variations on the prosperity of the Norse settlers of Iceland and Greenland.


## 2.2 Introduction

Seasonality of temperature, the difference between summer and winter temperatures, is one of the most important characteristics of climate (Andreasson and Schmitz, 2000) and plays a crucial role in determining the surface characteristics of the ocean (Williams et al., 1982). In order to develop a comprehensive global understanding of climate variability and to better predict future climate variability, it is critical that we acquire seasonality data from as many regions as possible (Barnett et al., 1999; Houghton et al., 1996). Innovations in sampling and analytical techniques have advanced such that subseasonal data can now be derived from accretionary materials; such as ice cores (e.g. Dansgaard et al., 1975) tree rings (e.g. Loader et al., 1995), speleothems (e.g. Lachniet et al., 2004), otoliths (e.g. Patterson et al., 1993), and molluscs (e.g. Wurster and Patterson, 2001). Because it is not possible to obtain appropriate proxy data from all areas of the globe over geologic timescales, it is important to focus our initial efforts on regions that are particularly sensitive to forcing mechanisms and that influence large-scale atmospheric and oceanic circulation patterns.

The North Atlantic region plays a particularly significant role in determining regional, hemispheric, and global climate variability (Hurdle, 1986). The North Atlantic Ocean is the site of bottom water formation that creates meridional overturning circulation (MOC). This brings warm surface water to the northern regions, thereby providing the northern latitudes of Western Europe and eastern North America with a temperate climate (Curry and Mauritzen, 2005), and is an integral component of global ocean circulation (Wunsch, 2002). The North Atlantic is also the site of atmospheric pressure centers that dominate the climate of the Northern Hemisphere (Barlow et al., 1997). In particular, the Icelandic Low and the Azores High pressure centers form the North Atlantic Oscillation (NAO). Changes in the intensity and position of these two pressure nodes influences the strength of the westerlies that dominate the temperature and precipitation of the Northern Hemisphere from eastern North American to western Asia (e.g. Hurrell, 1995).

Within the North Atlantic region, Iceland is exceptionally well positioned adjacent to oceanic and atmospheric cold Arctic and warm Atlantic fronts (Knudsen et al., 2004; Giraudeau et al., 2004) and is therefore an ideal location to develop paleoclimate records. Proxy records derived from Iceland also provide an important link between climate records of Greenland and Europe (Andrews et al, 2003). In particular, the continental shelves of Iceland, with a higher sedimentation rate (1-5m/kyr) than that of the open ocean areas (<1m/kyr), have the potential to archive climate change records with decadal-scale resolution (Smith et al., 2005). Recent studies of palaeoceanographic variation on the shelf and within the fjords of northern and northwestern Iceland have demonstrated that this area contains a record of oceanographic and atmospheric variability over the entire Holocene, and that these changes are representative of changes occurring in the wider North Atlantic region (e.g. Andrews et al., 2001a and b; Jennings et al., 2001; Andrews and Giraudeau, 2003; Andresen et al., 2005). In particular, numerous proxies of hydrographic change in the marine cores, including sedimentological characteristics, foraminiferal assemblages, and $\delta^{18}O$ values of foraminifera have indicated several warm and cold periods lasting hundreds to thousands of years have occurred over the past 10,000 to 12,000 calendar years.

To obtain seasonal records of change in this region, we have recovered proxy climate data from carbonate of marine bivalve shells obtained from shelf and fjord cores of northwest Iceland. We use $\delta^{18}O$ values of micromilled bivalves to reconstruct a series of monthly to sub-weekly temperature variation at discrete intervals of 2-9 years each from c. 360 cal yr BC to cal yr AD 1660. This period coincides with the time of exploration and exploitation of the waters and lands of the North Atlantic, the subsequent collapse of the Viking Settlements in Greenland and near collapse of the Icelandic Settlements.

## 2.3 Setting and modern oceanography

The modern hydrography of the Icelandic shelf is principally influenced by two surface water currents, the warm Irminger Current and the cold East Greenland Current. The Irminger Current (IC) is a branch of the North Atlantic Current that carries warm and saline Atlantic water northward from the subtropical Atlantic Ocean (Fig. 2.1). The IC bifurcates southwest of Iceland; one branch flows southwest, the other flows northward along western Iceland, then eastward along the north coast, becoming cooler and mixing with less saline water to become the North Icelandic Irminger Current (NIIC). The East Greenland Current (EGC) transports cold and lower salinity water, as well as sea ice and icebergs, southward from the Arctic. The EGC flows southward along eastern Greenland and branches northwest of Iceland, forming the East Icelandic Current that flows along the northern coast (Hurdle, 1986).

The climate of the North Atlantic region including eastern North America and western/northern Europe is strongly influenced by the interaction of the IC and EGC. Modern variability in the relative strength and position of these currents has been observed to take place on decadal timescales (Malmberg, 1985; Olafsson, 1999). During the "Great Salinity Anomaly" (GSA) of 1968-1982 (Dickson et al., 1988), minima in salinity and temperature time series were first detected off the northern coast of Iceland in 1965-1971 (Malmberg, 1969). Subsequent anomalies were noted around the North Atlantic throughout the 1970s, following a counterclockwise path from West Greenland to the Labrador Sea and off the coast of Newfoundland, then back to the central North Atlantic, northward to the Norwegian Sea by 1978-1979, and eventually back to the Greenland and Iceland Seas in 1981-1983 (Dickson et al., 1998; Belkin et al., 1998).

Cooler and less saline water observed in hydrographic sections north of Iceland (Malmberg, 1969), was accompanied by a period of severe ice conditions from 1968 to 1971 (Kelly et al., 1987). This event has been used as an analogy for conditions occurring during the peak cooling of the Little Ice Age (LIA) of northwest Europe, from the late 18$^{th}$ to the early 20$^{th}$ centuries (Lamb, 1979).

Modern atmospheric conditions in Iceland are dominated by the strength and position of the Icelandic Low and Greenland High that influence the direction and frequency of wind regimes and their subsequent effect on hydrographic conditions (Olafsson, 1999). When the Icelandic Low is strong, southerly and southeasterly winds are more prevalent, enhancing the flow of the IC and at the same time forcing the EIC further north (Giraudeau et al., 2004). Southerly wind regimes also cause increased convection in intermediate waters and further strengthen the Irminger Current (Kelly et al., 1987). A weak Icelandic Low and strong Greenland High drive a northerly/northwesterly wind regime and subsequently strengthen the EIC (Andresen, et al., 2005). This increases the amount of low salinity water in the Icelandic Sea, thereby restricting oceanic convection and promoting formation of sea-ice, creating a positive-feedback that further reduces temperatures (Kelly et al., 1987). Although the temperatures in Iceland do not correlate strongly to the NAO on a year-to-year basis (Olafsson, 1999), sustained periods (a decade or more) of strongly negative NAO regimes are associated with high pressure around Iceland and Greenland and subsequent decrease of convection in the Greenland and Iceland seas (Visbeck et al., 2003). Conversely, a sustained positive NAO state features a strong Iceland Low and a southerly wind regime, causing advection of warm air to Iceland and pushing the sea-ice northward (Hurrell et al., 2003; Visbeck et al., 2003).

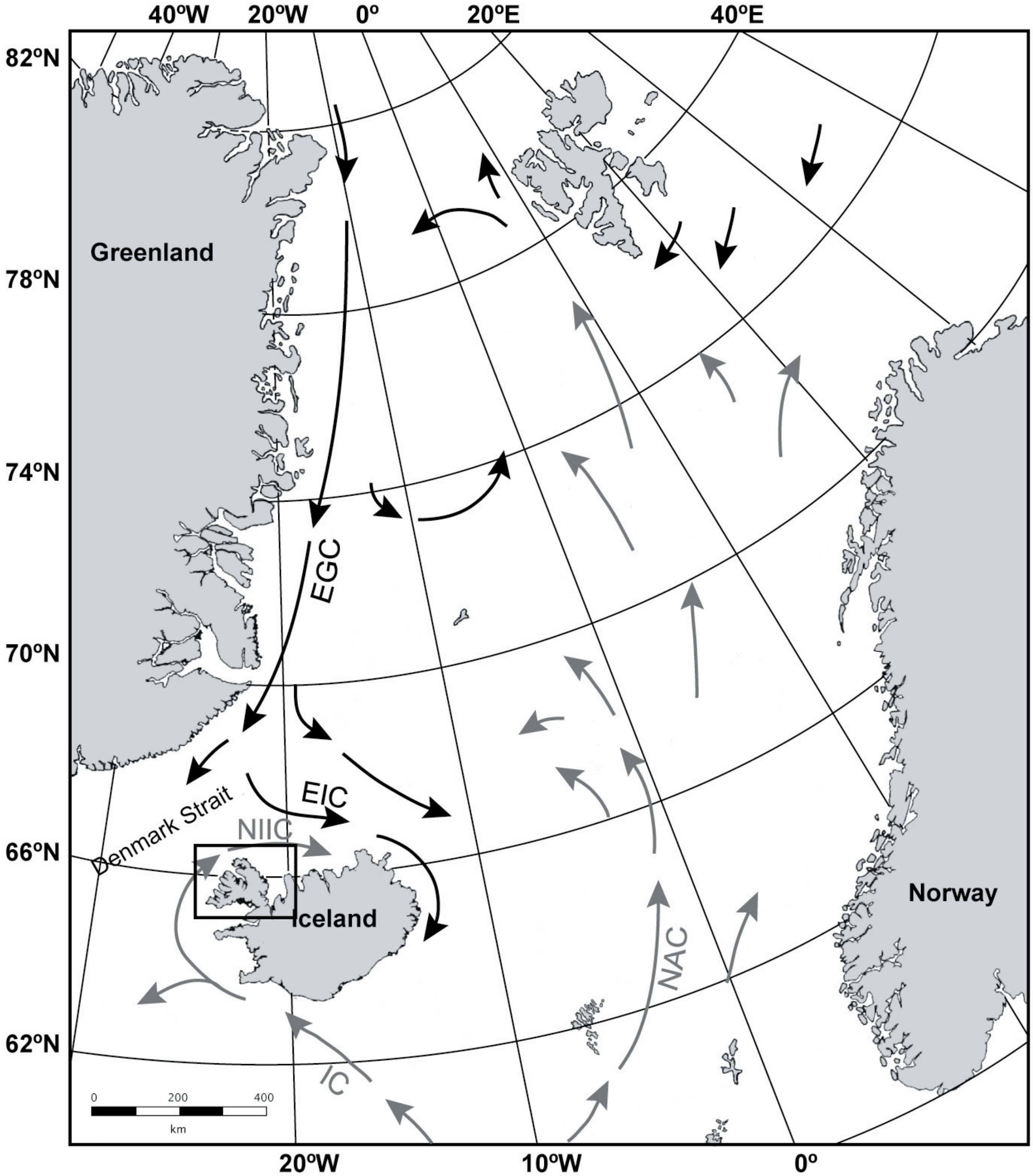


Fig. 2.1 Iceland and surrounding region. Black arrows indicate water currents of Arctic origin. EGC = East Greenland Current, EIC = East Icelandic Current. Gray arrows represent water currents of Atlantic origin. NAC = Norwegian Atlantic Current, IC = Irminger Current, NIIC = North Icelandic Irminger Current. Black rectangle outlines the region of study.

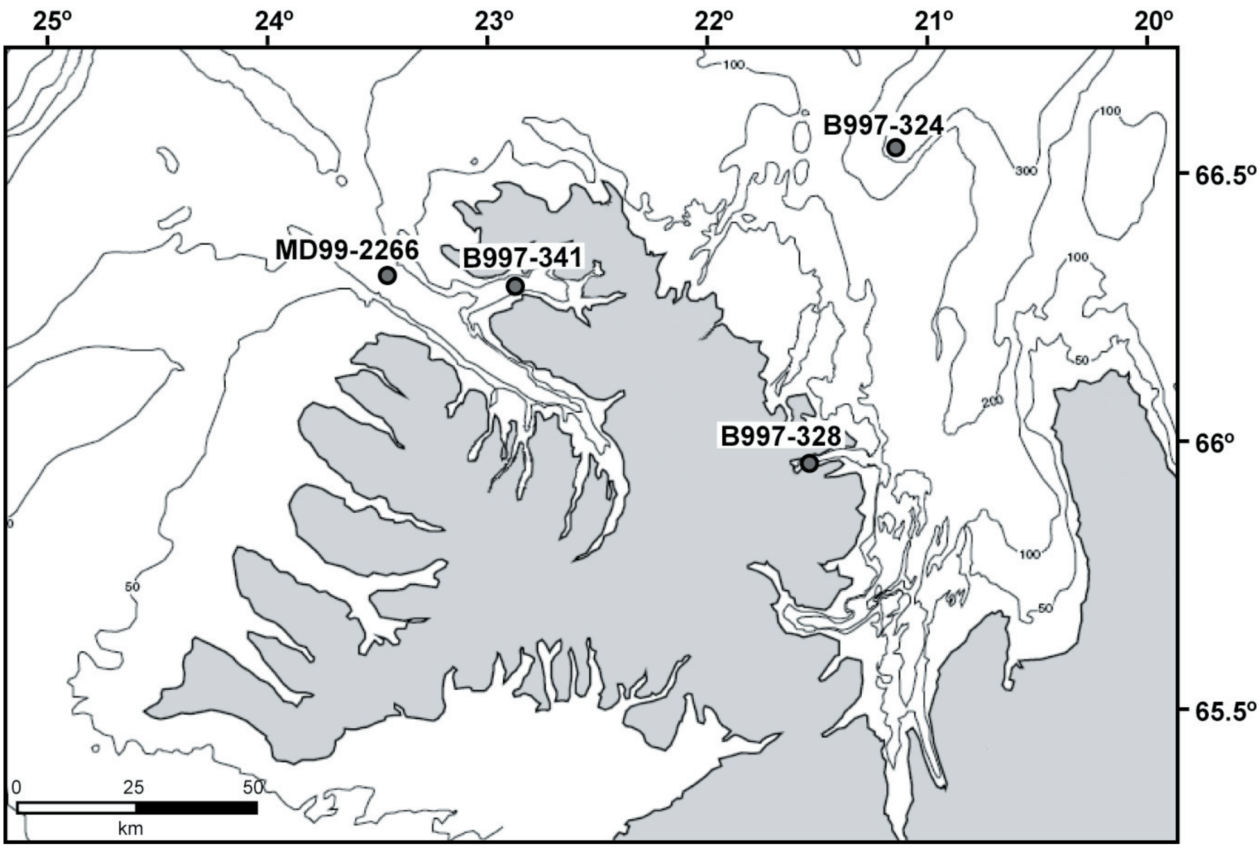


Fig. 2.2 Close-up of Vestfirdir, the northwest peninsula of Iceland, with locations of marine sediment cores.

## 2.4 Use of molluscan shell carbonate as a climate proxy

Shells of accretionary carbonate have long been used as a proxy for paleoenvironmental conditions. In particular, stable isotopes of oxygen and carbon in mollusc shell carbonate have been used to reconstruct water temperature (e.g. Urey, 1947; Epstein et al., 1951; 1953), $\delta^{18}O$ of water (e.g. Khim et al., 2001), timing of upwelling events (e.g. Jones et al., 1995; Killingley and Berger, 1979), and changes in salinity (Klein et al., 1996b). $\delta^{18}O$ values of bivalve shell carbonate have been demonstrated to precipitate in equilibrium with the temperature and $\delta^{18}O$ value of the ambient water (Wefer and Berger, 1983), therefore water temperatures can be reconstructed from $\delta^{18}O$ values of carbonate and an estimated $\delta^{18}O$ value of water, using an appropriate oxygen isotope carbonate fractionation relationship (e.g. Patterson et al., 1993). Advances in micromilling have enabled recovery of extremely high-resolution samples (Wurster et al., 1999), that allow for reconstruction of sub-seasonal, even sub-daily, temperature variability.

## 2.5 Materials and methods

A series of piston and gravity cores were collected in summer 1997 by the *Bjarni Saemundson* (Helgadottir, 1997), and in 1999 by the *RV Marion Dufresne* as part of the IMAGES V project (Jennings et al., 2001) off the northern and northwestern coasts of Iceland. Cores were x-radiographed and processed using standard sedimentological procedures (e.g. Knudsen and Eiriksson, 2002). Notable warm and cold intervals were initially estimated based on carbonate content. A total of twenty-six bivalves were extracted from four of the cores (MD99-2266, B997-324, -328, and -341; Table 2.1, Fig. 2.2) at stratigraphic intervals of carbonate maxima and minima, to obtain seasonal climate information during climatic extremes.

One valve of each bivalve was cleaned, and the interior was filled with epoxy to stabilize the shell. When dry, the shell was affixed to a standard microscope slide that was subsequently mounted on a computer-controlled stage of a robotic micromilling device. Growth banding was digitized as x-y-z coordinates, and intermediate sample paths were interpolated using a cubic spline. The shell is milled along paths concordant with growth structures (Wurster et al., 1999). Carbonate samples of ~20-50μg were recovered for analysis. Samples were roasted *in vacuo* at 200ºC for 2 hours to remove volatile contaminants. Samples were then loaded in a Kiel III automated carbonate preparation device coupled to a Thermo-Finnigan MAT 253 dual-inlet gas-ratio mass spectrometer, where they reacted with 4 drops of 103% phosphoric acid for 3 minutes at 70ºC.

$CO_2$ produced from the reaction is analyzed and isotope values are corrected for phosphoric acid fractionation and $^{17}O$ contribution. Values are reported as ‰ deviations from the VPDB standard using NBS-19 as well as internal laboratory standards. Precision is ±0.07‰ and ±0.11‰ ($1\sigma$) for $\delta^{13}C$ and $\delta^{18}O$, respectively (based on 397 NBS-19 samples).

**Table 2.1** Locations and properties of cores

| Site Number | Longitude (W) | Latitude (N) | Water depth (m) | Core length (cm) |
|---|---|---|---|---|
| B997-324 | 21º09.13' | 66º31.43' | 282 | 300 |
| B997-328 | 21º32.90' | 65º57.42' | 94 | 422 |
| B997-341 | 22º50.53' | 66º16.62' | 96 | 250 |
| MD99-2266 | 23º15.93' | 66º13.77' | 106 | 3900 |

In order to establish an estimate of the relationship between the sampling path width and the variation in isotope value, the first shell to be analyzed (MD99-2266/112-113cm) was micromilled at varying path widths, and every carbonate sample was analyzed for carbon and oxygen isotope values. This shell, species *Thyasira flexuosa*, was selected as being representative in size and thickness to the majority of the other shells. Analysis of these samples revealed that a path width of 30-50μm was sufficient to obtain maximum resolution, and that measurement of every 10$^{th}$ sample provided a basic isotope profile, which was then further clarified by analyzing appropriate samples to obtain the full range of seasonal extremes. In subsequent shells, similar path widths were used, but varied depending on the species, size, and thickness of the shell. Typically every 5$^{th}$ sample for shells with < 300 samples recovered was analyzed, and every 10th sample for shells with >300 samples recovered.

**2.5.1 Paleotemperature calculations**

Bivalve carbonate is precipitated in equilibrium with the $\delta^{18}O_{water}$ value in accord with a temperature fractionation relationship that allows for calculation of past water temperature (e.g. Epstein et al., 1953). The molluscs analyzed in this study produce aragonitic shells; therefore paleotemperatures were calculated using the aragonite-fractionation equation of Patterson et al. (1993):

$$1000\ln\alpha = 18.56\ (10^3T(K)^{-1})\ -33.49 \qquad \text{(Eq. 1)}$$

where

$$\alpha = (1000 + \delta^{18}O_{aragonite}/1000 + \delta^{18}O_{water}) \qquad \text{(Eq. 2)}$$

and $\delta^{18}O_{aragonite}$ and $\delta^{18}O_{water}$ are both expressed relative to VSMOW. $\delta^{18}O_{aragonite}$ values were converted from VPDB to VSMOW using the conversion equation of Coplen et al. (1983):

$$\delta^{18}O_{VSMOW} = 1.03091 * \delta^{18}O_{VPDB} + 30.91 \qquad \text{(Eq. 3)}$$

A $\delta^{18}O_{water}$ value of 0.1‰ VSMOW was used in the palaeotemperature equation based on measurements of modern $\delta^{18}O_{water}$ in the region from the Goddard Institute for Space Studies (http://data.giss.nasa.gov/o18data/) and from $\delta^{18}O_{water}$ values determined for samples taken on the B997 cruise (Smith et al., 2005). Samples taken from 50-250m water depth have an average $\delta^{18}O$ value of 0.14‰ VSMOW (-0.19‰ to 0.35‰ VSMOW).

### 2.5.2 Radiocarbon dating

Bivalve ages were determined by AMS $^{14}C$ dating of bivalves and one gastropod (Table 2.2). Several micromilled bivalves that were analysed were subsequently dated with AMS $^{14}C$, while intermediate bivalves were dated by interpolation between radiocarbon dates (Fig. 2.3). Radiocarbon dates were converted into calibrated years using the marine 04.14c dataset (Houghten et al., 2004) of CALIB5.0.2 (http://radiocarbon.pa.qub.ac.uk/calib/), based on the calibration program of Stuiver and Reimer (1993). This dataset includes a standard marine reservoir correction of ~400 years. This value is a global average reservoir age (the difference in $^{14}C$ age between the atmosphere and the ocean), as reservoir ages vary geographically (Stuiver and Braziunas, 1993). Studies comparing radiocarbon and tephrochronological ages of marine cores off the northern coast of Iceland have found discrepancies between the two, indicating that the reservoir age has been subject to change in the past (Eiriksson et al., 2000a and b). When Arctic waters dominate the shelf, the reservoir age appears to be as high as 800 years (Eiriksson et al., 2000a). However, these studies were conducted on cores that were further north than those used in our study and are more strongly influenced by Arctic water than sites closer to shore (Giraudeau et al., 2004). For near-shore sites, comparison between radiocarbon and tephrochronological dates of the Saksunavatn tephra has demonstrated that a reservoir age of 400 years is acceptable for near-shore sites on the north Icelandic shelf (Castaneda, et al., 2004; Andrews et al., 2002; Giraudeau et al., 2004). The Saksunavatn tephra is also present in core MD99-2266, from which the majority of molluscs were obtained for our study. The age of this layer is 10,180 cal yr BP (Grönvold et al., 1995), which is in agreement with the radiocarbon dates of MD99-2266, using a reservoir age of 400 years (Quillmann, pers. comm.)

**Table 2.2** Radiocarbon dates. See Dunhill et al. (2004) and Smith and Licht (2001) for additional details on samples

| Core | Depth (cm) | Laboratory number | $^{14}C$ yr BP ($\pm 1\sigma$) | Calibrated age range ($1\sigma$) cal yr BP | Calibrated age range ($2\sigma$) cal yr BP | median cal yr BP | Material | Name | $\delta^{13}C$ (‰VPDB) |
|---|---|---|---|---|---|---|---|---|---|
| B997-324 | 30-32 | NSRL12567 | 1800±30 | 1299-1367 | 1273-1408 | 1337 | Bivalve | *Astarte borealis* | 2.6 |
| B997-328 | 3.75-5 | NSRL10182 | 175±65 | modern | modern | modern | Gastropod | *Turritella* | 0.6 |
| B997-328 | 35-36.25 | NSRL10673 | 550±35 | 140-248 | 66-276 | 186 | Bivalve | partial shell | -0.8 |
| B997-328 | 73.75-76.25 | NSRL10680 | 800±40 | 410-488 | 328-503 | 441 | Bivalve | *Nucula* | 0.3 |
| B997-328 | 108-110 | CAMS46520 | 1460±50 | 941-1057 | 907-1135 | 1008 | Bivalve | *Nuculana* | 0 |
| B997-328 | 125 | CAMS46521 | 1230±50 | 706-829 | 674-890 | 774 | Bivalve | *Nucula* | 0.5 |
| B997-328 | 168-169 | CAMS46522 | 1970±50 | 1455-1597 | 1393-1669 | 1525 | Bivalve | *Yoldia* | -1.2 |
| B997-328 | 257-259 | CAMS46523 | 2660±50 | 2295-2424 | 2184-2513 | 2354 | Bivalve | *Macoma* | -1.1 |
| B997-341 | 7 | CURL5892 | 610±35 | 226-301 | 129-329 | 258 | Bivalve | *Nucula* cf. *pernula* or *tenuis* | -0.1 |
| B997-341 | 32.5 | AA51048 | 1006±32 | 553-622 | 527-645 | 588 | Bivalve | *Nucula* cf. *tenuis* | 1.9 |
| B997-341 | 58.5 | AA51049 | 1453±62 | 925-1060 | 884-1162 | 1004 | Bivalve | unidentified | -0.1 |
| B997-341 | 66.25 | CURL7634 | 1620±15 | 1163-1225 | 1127-1252 | 1192 | Bivalve | *Thyasira flexuosa* | 2.3 |
| B997-341 | 92 | CURL5893 | 1760±35 | 1272-1337 | 1244-1382 | 1307 | Bivalve | *Macoma* sp. | 0.7 |
| MD99-2266 | 0-3 | AA35804 | 780±40 | 381-476 | 315-491 | 422 | Bivalve | unidentified | -6.5 |
| MD99-2266 | 9.5-10.5 | AA67746 | 822±67 | 394-517 | 301-543 | 449 | Bivalve | *Macoma calcarea* | n/a |
| MD99-2266 | 24-25 | AA67747 | 746±61 | 319-443 | 279-488 | 385 | Bivalve | *Thyasira flexuosa* | 1 |
| MD99-2266 | 34-36 | AA58537 | 809±30 | 428-483 | 373-507 | 453 | Bivalve | *Nuculana tenuisulacata* | n/a |
| MD99-2266 | 72-74 | AA53619 | 1151±53 | 651-743 | 614-827 | 702 | Bivalve | *Thyasira flexuosa (sarsi?)* | n/a |
| MD99-2266 | 112-113.5 | CURL7633 | 1450±15 | 957-1024 | 931-1050 | 991 | Bivalve | *Thyasira flexuosa* | 3.3 |
| MD99-2266 | 139-141 | AA53536 | 1640±33 | 1170-1248 | 1119-1278 | 1206 | Scaphopod | *Dentalium* sp. | n/a |
| MD99-2266 | 162.5-163.5 | AA53620 | 1800±45 | 1290-1380 | 1260-1462 | 1342 | Bivalve | *Nuculana pernula* | 0.9 |
| MD99-2266 | 194-196 | AA59338 | 2126±34 | 1668-1780 | 1603-1814 | 1715 | Bivalve | *Thyasira* sp. | n/a |
| MD99-2266 | 239-241 | AA58971 | 2664±35 | 2304-2397 | 2279-2474 | 2352 | Bivalve | *Yoldia* (?) | n/a |
| MD99-2266 | 258.5-259.5 | AA50033 | 2503±36 | 2115-2246 | 2060-2292 | 2175 | Bivalve | *Astarte* sp. | -2.6 |

AA—University of Arizona AMS Facility
CAMS—Center for AMS at Lawrence Livermore National Laboratory
CURL—Laboratory for Radiological Dating in Trondheim, Norway
NSRL—INSTAAR Radiocarbon Laboratory, samples run at Woods Hole

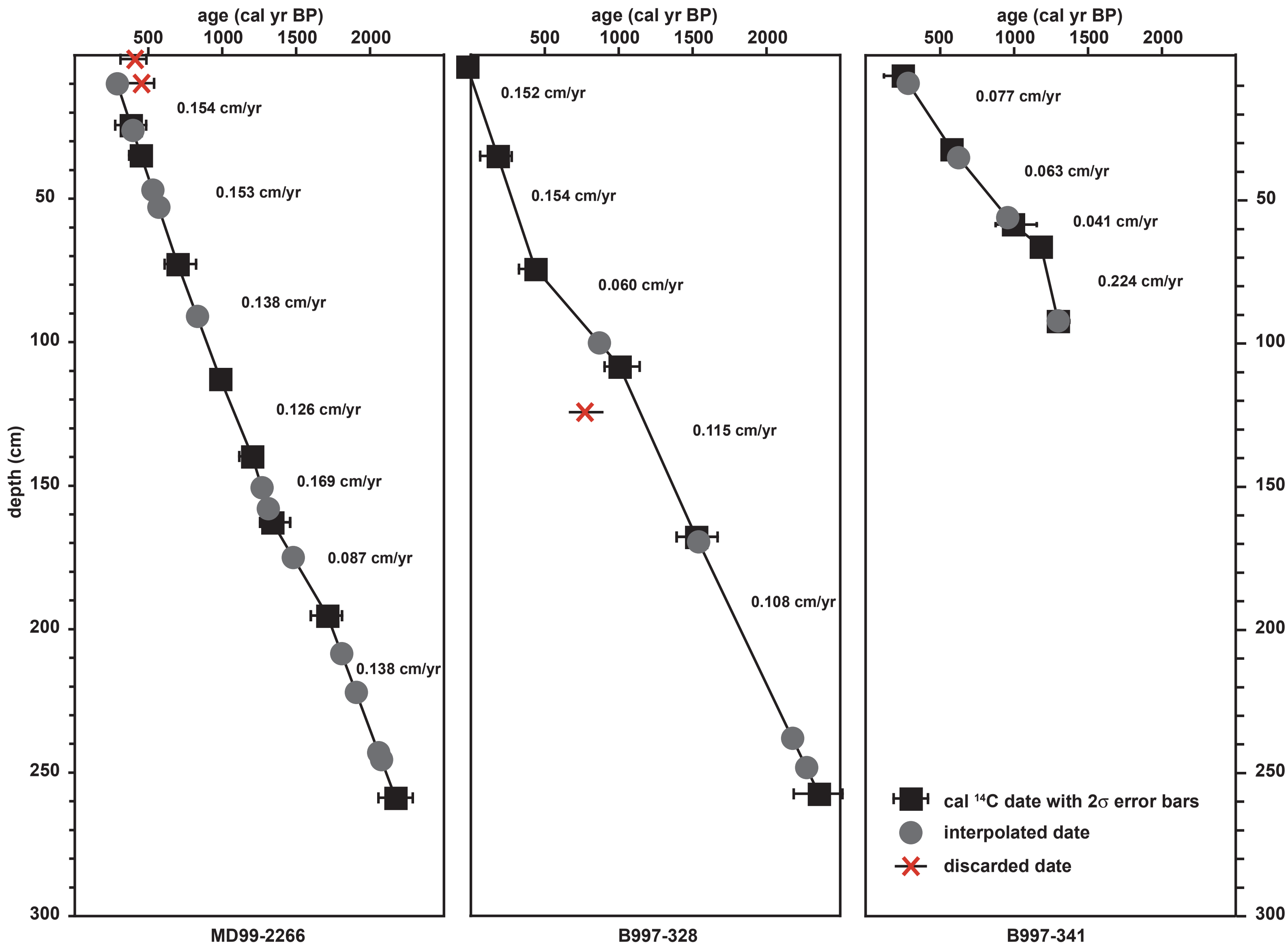


Fig. 2.3 Age-depth models for cores MD99-2266, B997-328, and B997-341 based on calibrated radiocarbon ages (see Table 2.2). Sedimentation rate is based on the accumulation rate in centimeters per year and is determined from the age model.

## 2.6 Results

### 2.6.1 $\delta^{18}O$ and temperature

$\delta^{18}O$ values of carbonate are dependent on both temperature and the $\delta^{18}O_{water}$ value of ambient seawater. Although this is a consideration in reconstruction of past temperatures, modern hydrographic conditions on the north Icelandic shelf indicate that temperature is the dominant variable. Measurements of temperature and salinity of waters off the northern and northwest coast taken since 1938 are available from the Marine Research Institute of Iceland (www.hafro.is). Bottom water temperatures in our study area have ranged from -1.5 to 10.5ºC, and bottom water salinities have ranged from 33.99 to 35.15‰. Salinity and $\delta^{18}O_{water}$ values respond similarly to physical processes (e.g. both increase due to evaporation), and so they often co-vary. A mixing line relating salinity to $\delta^{18}O_{water}$ for north Icelandic waters has been developed by Smith et al., 2005:

$$\delta^{18}O_{H2O} = 0.32 * S‰ - 10.99 \quad \text{(Eq. 4)}$$

such that the total salinity variability measured since 1938 corresponds to a ~0.4‰ range in $\delta^{18}O_{water}$ values, which corresponds to a ~1.7ºC temperature using our palaeotemperature equation. The greater range of water temperatures compared to the range of salinity indicates that temperature dominates the $\delta^{18}O_{CaCO3}$ values of shells precipitated in northern Icelandic shelf waters. Therefore the error of our reconstructed temperatures due to uncertainty in the $\delta^{18}O_{water}$ value is less than +/- 1ºC.

Variations in $\delta^{18}O_{CaCO3}$ values are therefore interpreted as corresponding to changes in temperature rather than in the $\delta^{18}O_{water}$ value. $\delta^{18}O$ values and their corresponding temperatures measured in the oldest bivalve in our record are presented in Fig. 2.4, plotted versus sample number from umbo to the outer margin. Minimum $\delta^{18}O$ values are interpreted as the highest temperatures and maximum $\delta^{18}O$ values are interpreted as the lowest temperatures. Each year of growth interpreted from $\delta^{18}O$ values was corroborated when possible with visible annual growth lines on the surface of the shell that representing periods of slow growth. $\delta^{18}O$ values of the oldest bivalve indicate that it lived for four summers and three winters. As bivalves age, it is typical for the growth period to shorten (shutdown period to lengthen), and thus for the shell deposited to record less of the growing season (Schöne et al., 2005). This results in an oxygen isotope profile with decreasing amplitude over the life of the mollusk (Goodwin et al., 2003). Oxygen isotope profiles were evaluated for such ontogenetic effects, and values that appeared to not represent a full season of growth were not used. The maximum, minimum and average of summer high and winter low temperatures for each bivalve are summarized in Table 2.3. Overall $\delta^{18}O$ values ranged from 4.4 to 1.4‰ VPDB, corresponding to a temperature range of –1° to 12.9ºC, while the maximum variation within a single shell was 2.0‰ VPDB, corresponding to an 8.5ºC temperature range.

Although coastal bottom water temperatures are being reconstructed in this study, changes in water temperature are influenced by the same meteorological conditions that control air temperatures in Iceland. Decreases in water temperature are caused by advection of the East Greenland Current closer to northern Iceland and is strongly influenced by the strength of northerly winds; increases in temperature are a result of advection of the Irminger Current caused by stronger southerly winds (Olafsson, 1999). Lower water temperatures are also associated with greater sea-ice presence off the northern coasts, which has a strong influence on surface air temperatures (Kelly, 1987). For example, spring water temperature measured off the northern coast of Iceland at 100m depth in 1967 (during the GSA) was 2.6ºC lower than the 1961-1991 average (Marine Research Institute, www.hafro.is), while in the same year the average March temperature was 5.1ºC lower than the 1961-1991 average (Icelandic Meteorological Office, www.vedur.is). The reconstructed water temperatures do not represent the range of air temperatures, but they do reflect trends in the atmospheric conditions that affect the air temperature, and subsequently the inhabitants of Iceland.

The resolution obtained can be estimated by the number of samples collected between two maxima or two minima $\delta^{18}O_{CaCO3}$ values. For example, in examination of the bivalve data presented in Fig. 2.3, 149 samples were obtained for the first two summers of growth. Maximum sampling resolution for all bivalves is shown in Table 2.3. Resolution varies from 43 to 160 samples per year, and is dependent upon the size and thickness of the shell and the shell growth rate. Sampling at the highest resolution in this study provides data with approximately two-day resolution.

Although comparison of reconstructed temperatures from different cores is not ideal, the CTD (conductivity, temperature, and depth) measurements taken during the B997 cruise (Smith et al., 2005) indicate that the only core with a significant difference in temperature was core B997-328, which was 0.8 – 1.3ºC cooler than bottom water from the other core locations. In order to compare temperatures between cores, 1ºC was added to the calculated temperatures of shells from B997-328.

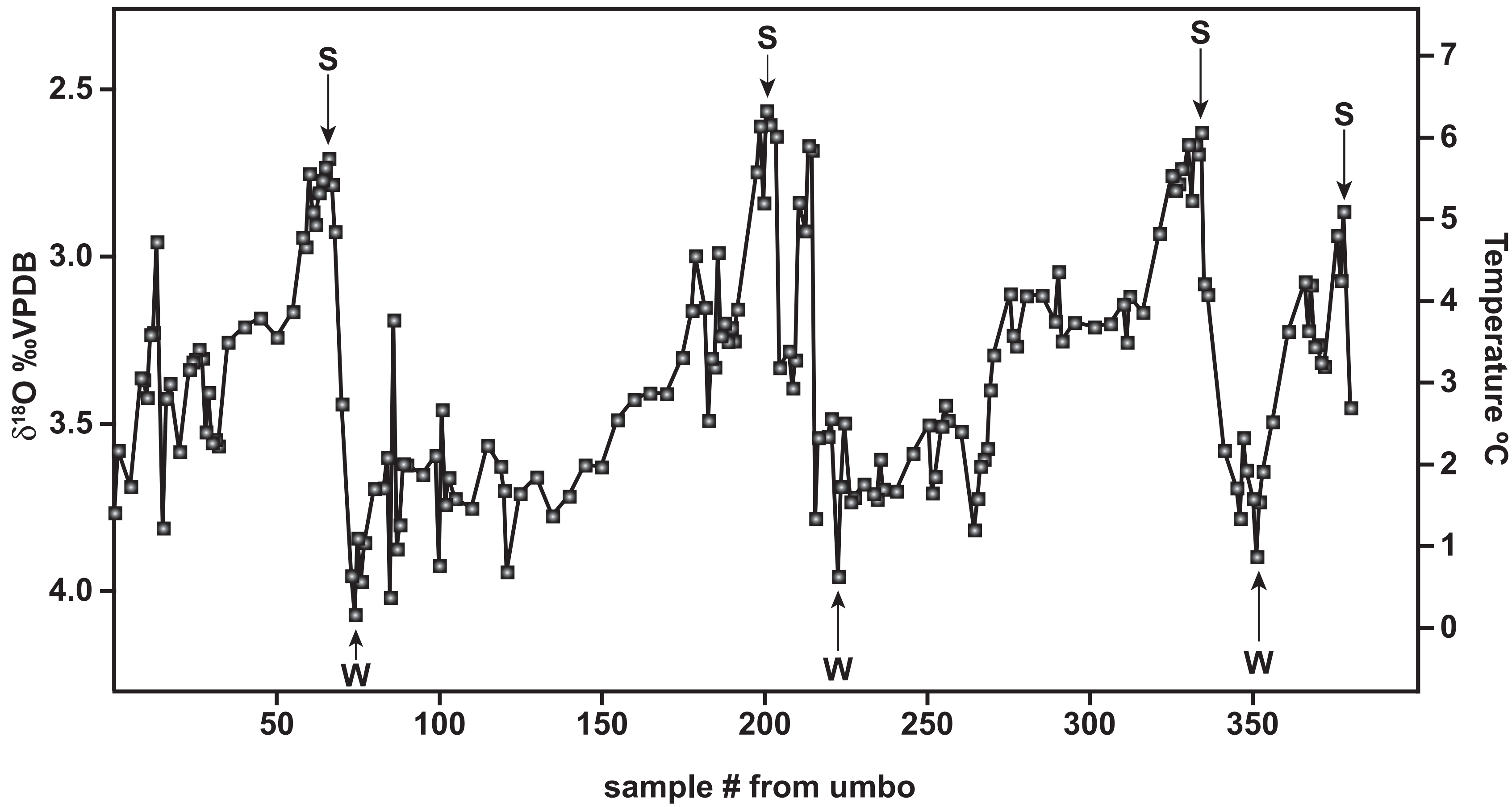


Fig. 2.4 $\delta^{18}O_{aragonite}$ values of shell B997-328\248.75-257.25cm (left axis) and corresponding temperatures (right axis). Arrows point to maximum and minimum annual temperatures, S (summer) is the maximum annual temperature, W (winter) is the minimum annual temperature.

**Table 2.3** Summary of bivalve data

| Core | Depth (cm) | Species | Median cal yr BC/AD (± 1σ) | Minimum summer high temperature (ºC) | Maximum summer high temperature (ºC) | Average summer high temperature (ºC) | Minimum winter low temperature (ºC) | Maximum winter low temperature (ºC) | Average winter low temperature (ºC) | Maximum resolution (samples/yr)* |
|---|---|---|---|---|---|---|---|---|---|---|
| B997-328 | 248.75-257.25 | *Tellina tenuis* | -360±70 | 5.7 | 6.3 | 6.0 | 0.2 | 0.9 | 0.5 | 149 |
| B997-328 | 238.5-241.25 | *Tellina tenuis* | -240±70 | 4.1 | 5.8 | 5.1 | -1.0 | 1.0 | 0.0 | 73 |
| MD99-2266 | 258.5-259.9 | *Thyasira flexuosa* | -230±70 | 8.1 | 11.3 | 10.1 | 4.8 | 6.2 | 5.4 | 91 |
| MD99-2266 | 244-245.5 | *Thyasira flexuosa* | -130±70 | 7.3 | 12.9 | 9.6 | 3.1 | 4.8 | 3.9 | 120 |
| MD99-2266 | 241.5-243 | *Thyasira flexuosa* | -110±70 | 6.6 | 9.1 | 7.2 | 3.2 | 4.8 | 3.9 | 57 |
| MD99-2266 | 222 | *Thyasira flexuosa* | 40±70 | 7.7 | 9.6 | 8.6 | 2.5 | 3.7 | 3.1 | 76 |
| MD99-2266 | 208-209 | *Tellina tenuis* | 140±65 | 7.7 | 8.6 | 8.2 | 2.1 | 2.9 | 2.5 | 95 |
| B997-328 | 168.75-171.25 | *Nuculana tenuisulacata* | 410±70 | 4.2 | 6.4 | 5.6 | -0.5 | 1.2 | 0.7 | 96 |
| MD99-2266 | 174.5-175.5 | *Macoma calcarea* | 470±50 | 6.6 | 7.7 | 7.2 | 0.9 | 3.7 | 2.5 | 75 |
| B997-324 | 30-32 | *Astarte borealis* | 610±65 | 7.0 | 8.6 | 7.8 | 2.6 | 4.2 | 3.7 | 35 |
| MD99-2266 | 157-159 | *Thyasira flexuosa* | 640±50 | 8.1 | 8.7 | 8.3 | 3.1 | 5.4 | 4.1 | 119 |
| B997-341 | 91.75 | *Thyasira flexuosa* | 640±35 | 10.7 | 11.8 | 11.4 | 4.9 | 6.6 | 5.7 | 43 |
| MD99-2266 | 150-151.5 | *Thyasira flexuosa* | 680±45 | 7.2 | 8.3 | 7.7 | 1.4 | 3.4 | 2.6 | 198 |
| B997-341 | 66.25 | *Thyasira flexuosa* | 760±35 | 8.8 | 9.3 | 9.1 | 4.3 | 6.1 | 5.4 | 29 |
| MD99-2266 | 112-113.5 | *Thyasira flexuosa* | 960±35 | 7.4 | 9.6 | 8.3 | 1.1 | 1.1 | 1.1 | 107 |
| B997-341 | 56 | *Nuculana tenuisulacata* | 990±75 | 5.2 | 6.8 | 6.2 | 0.7 | 2.1 | 1.4 | 66 |
| B997-328 | 100-101.25 | *Nuculana tenuisulacata* | 1080±60 | 3.8 | 6.0 | 5.2 | 0.0 | 0.9 | 0.4 | 40 |
| MD99-2266 | 90-92 | *Nuculana tenuisulacata* | 1120±45 | 5.9 | 5.9 | 5.9 | 0.6 | 0.6 | 0.6 | 96 |
| MD99-2266 | 72-74 | *Thyasira flexuosa* | 1250±50 | 7.3 | 9.8 | 7.9 | 1.9 | 3.3 | 2.8 | 160 |
| B997-341 | 35.25 | *Nuculana tenuisulacata* | 1320±40 | 7.5 | 7.5 | 7.5 | 1.5 | 2.8 | 2.2 | 152 |
| MD99-2266 | 53 | *Tellina tenuis* | 1380±40 | 4.1 | 5.2 | 4.6 | -0.4 | -0.4 | -0.4 | 53 |
| MD99-2266 | 46.5-47.5 | *Nuculana tenuisulacata* | 1420±35 | 5.4 | 6.0 | 5.7 | 0.1 | 1.6 | 0.8 | 68 |
| MD99-2266 | 26-26.5 | *Astarte cf. castanea* | 1550±60 | 7.1 | 7.3 | 7.2 | 1.1 | 1.6 | 1.4 | 127 |
| MD99-2266 | 24-25 | *Thyasira flexuosa* | 1570±65 | 8.7 | 8.7 | 8.7 | 1.9 | 2.3 | 2.1 | 142 |
| MD99-2266 | 9.5-10.5 | *Macoma calcarea* | 1660±125 | 5.2 | 7.5 | 6.7 | 0.8 | 2.6 | 1.7 | 67 |
| B997-341 | 9.5 | *Thyasira flexuosa* | 1660±40 | 7.2 | 11.3 | 9.4 | 3.6 | 3.9 | 3.7 | 63 |

* a year is defined as the distance between two consecutive maximum or two minimum $\delta^{18}O$ values

### 2.6.2 $\delta^{13}C$ and metabolism

Unlike $\delta^{18}O$, $\delta^{13}C$ values of shell carbonate do not generally precipitate in equilibrium with the $\delta^{13}C$ value of dissolved inorganic carbon (DIC) of the surrounding water. Some researchers have found that $\delta^{13}C$ values are controlled by the $\delta^{13}C$ value of the DIC (e.g. Mook and Vogel, 1968), while others have found that metabolic carbon makes a significant contribution to the $\delta^{13}C$ value of the shell (e.g. Tanaka et al., 1986). Metabolic carbon is derived from respiratory $CO_2$, and has a lower $\delta^{13}C$ value than external carbon sources because the organic material ingested as food has lower $\delta^{13}C$ values (Lorrain et al., 2004). Thus, as metabolic activity increases, the $\delta^{13}C$ value of shell carbonate should decrease.

Metabolism in marine invertebrates is influenced by several factors, including ambient temperature, age of organism, and growth rate (Purton et al., 1999), as well as food availability and reproduction (Brockington and Clarke, 2001). Higher temperatures and increased food availability in the summer lead to increased metabolic activity (Brockington and Clarke, 2001; Schone et al., 2005), which further increases the contribution of metabolic $CO_2$ to the shell, resulting in decreasing $\delta^{13}C$ values. Thus, $\delta^{13}C$ and $\delta^{18}O$ values will co-vary if the $\delta^{13}C$ values are dominated by metabolic $CO_2$. Six of the bivalve records display significant positive correlations ($R^2 > 0.3$) between $\delta^{13}C$ and $\delta^{18}O$ values (Fig. 2.5 – 2.7), species *Astarte borealis* and *Thyasira flexuosa*. It is difficult to relate this trend to species, as there was only one specimen of *A. borealis*, and although *T. flexuosa* are more numerous, the correlation coefficients range from 0 to 0.73 (Table 2.4). One of the records shows significant negative correlation (Fig. 2.8), species *Tellina tenuis*, but other individuals of that species show no correlation. There is a general trend for larger individuals (greater shell height) to have higher correlation between $\delta^{13}C$ and $\delta^{18}O$ values (Table 2.4), but it does not explain all of the variation. Several of the shells have $\delta^{13}C$ values that decrease with ontogeny, a common phenomenon in short-lived bivalves (Krantz et al., 1987, Klein et al., 1996, Schöne et al., 2005). This is thought to arise from a greater incorporation of metabolic carbon into the shell as it ages, perhaps in relation to the onset of sexual maturity (Jones et al., 1995), although this process is not well understood.

As $\delta^{13}C$ values of shell carbonate are influenced by $\delta^{13}C_{diet}$, thus $\delta^{13}C_{shell}$ can vary by taxon and mode of feeding (Khim et al., 2001;Wefer and Berger, 1999). $\delta^{13}C$ values of carbonate from bivalves that feed on phytoplankton (i.e. filter feeders) may be lower than that from bivalves that feed on detrital organic matter (i.e. deposit feeders), as phytoplankton generally has lower $\delta^{13}C$ values than detrital organic matter (Khim et al., 2001). The species *Thyasira flexuosa* is known to contain a symbiotic sulfur-oxidizing bacteria that contributes to the bivalve carbon reservoir thereby resulting in lower tissue and shell $\delta^{13}C$ values compared to other species that lack this bacterium (Dando et al., 1985; Dando et al., 1993). $\delta^{13}C$ values of *Thyasira flexuosa* in this study range from -3 to -8 ‰ VPDB, compared to a range of -3 to 3 ‰ for all other species (Table 2.4).

**Table 2.4** Summary of carbon isotope data

| Species | Core | Depth (cm) | Minimum $\delta^{13}C$ (‰ VPDB) | Maximum $\delta^{13}C$ (‰ VPDB) | Correlation ($R^2$) $\delta^{13}C$ and $\delta^{18}O$ (negative) | Shell height (cm) |
|---|---|---|---|---|---|---|
| *Astarte borealis* | B997-324 | 30-32 | -0.67 | 1.97 | 0.73 | 8.1 |
| *Astarte cf. castanea* | MD99-2266 | 26-26.5 | 0.20 | 2.38 | (0.02) | 3.1 |
| *Macoma calcarea* | MD99-2266 | 174.5-175.5 | -0.64 | 1.05 | 0.01 | 2.5 |
| *Macoma calcarea* | MD99-2266 | 9.5-10.5 | -0.08 | 1.69 | 0.1 | 2.9 |
| *Nuculana tenuisulacata* | B997-328 | 168.75-171.25 | -0.79 | 2.24 | 0 | 4.6 |
| *Nuculana tenuisulacata* | B997-328 | 100-101.25 | -1.45 | 1.52 | 0.06 | 2.0 |
| *Nuculana tenuisulacata* | B997-341 | 56 | -0.07 | 1.52 | 0.01 | 1.8 |
| *Nuculana tenuisulacata* | B997-341 | 35.25 | -1.15 | 0.94 | (0.05) | 3.4 |
| *Nuculana tenuisulacata* | MD99-2266 | 90-92 | -1.30 | 1.15 | (0.03) | 4.3 |
| *Nuculana tenuisulacata* | MD99-2266 | 46.5-47.5 | 0.48 | 1.73 | (0.04) | 2.3 |
| *Tellina tenuis* | B997-328 | 248.75-257.25 | -1.24 | 1.60 | (0.02) | 3.2 |
| *Tellina tenuis* | B997-328 | 238.5-241.25 | -2.60 | 2.04 | 0.08 | 3.1 |
| *Tellina tenuis* | MD99-2266 | 208-209 | -0.75 | 1.64 | 0.07 | 3.2 |
| *Tellina tenuis* | MD99-2266 | 53 | 0.35 | 1.45 | (0.51) | 1.5 |
| *Thyasira flexuosa* | B997-341 | 91.75 | -4.62 | -2.62 | 0.04 | 2.6 |
| *Thyasira flexuosa* | B997-341 | 66.25 | -6.78 | -2.53 | (0.02) | 1.8 |
| *Thyasira flexuosa* | B997-341 | 9.5 | -8.17 | -1.10 | 0.73 | 3.4 |
| *Thyasira flexuosa* | MD99-2266 | 258.5-259.9 | -3.93 | -0.37 | 0.47 | 3.7 |
| *Thyasira flexuosa* | MD99-2266 | 244-245.5 | -5.05 | 0.14 | 0.54 | 6.2 |
| *Thyasira flexuosa* | MD99-2266 | 241.5-243 | -3.13 | -0.11 | 0.14 | 5.5 |
| *Thyasira flexuosa* | MD99-2266 | 222 | -5.66 | -0.03 | 0.21 | 6.1 |
| *Thyasira flexuosa* | MD99-2266 | 157-159 | -4.03 | -0.60 | 0.01 | 6.4 |
| *Thyasira flexuosa* | MD99-2266 | 150-151.5 | -6.29 | -1.61 | 0.25 | 6.9 |
| *Thyasira flexuosa* | MD99-2266 | 112-113.5 | -5.04 | -0.86 | 0.32 | 5.8 |
| *Thyasira flexuosa* | MD99-2266 | 72-74 | -7.39 | -1.98 | 0.36 | 10.7 |
| *Thyasira flexuosa* | MD99-2266 | 24-25 | -3.29 | 0.13 | (0.14) | 5.4 |

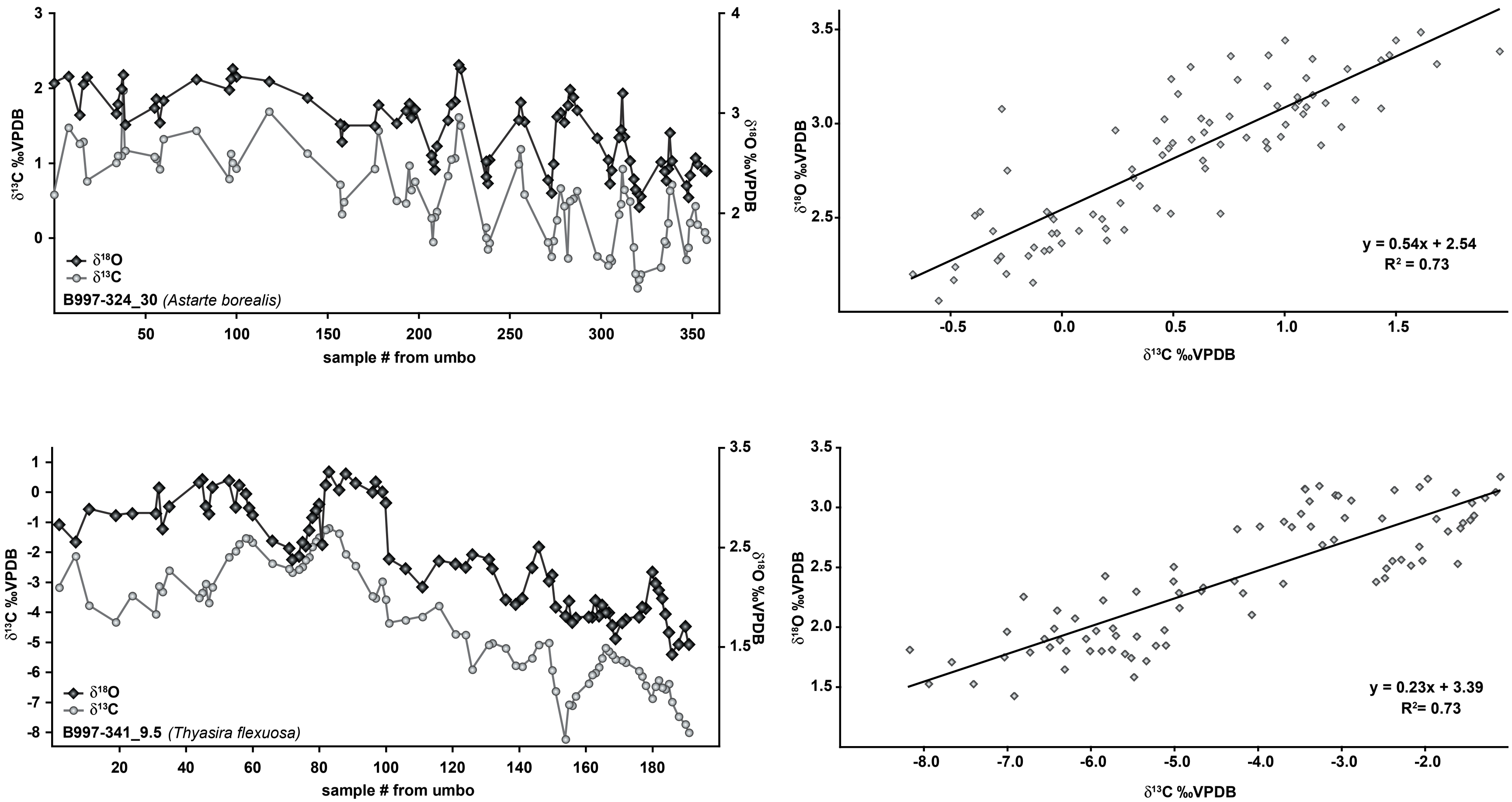


Fig. 2.5. $\delta^{13}C$ and $\delta^{18}O$ profiles (left) and correlation between $\delta^{13}C$ and $\delta^{18}O$ (right) of shell B997-324_30 (upper) and B997-341_9.5 (lower).

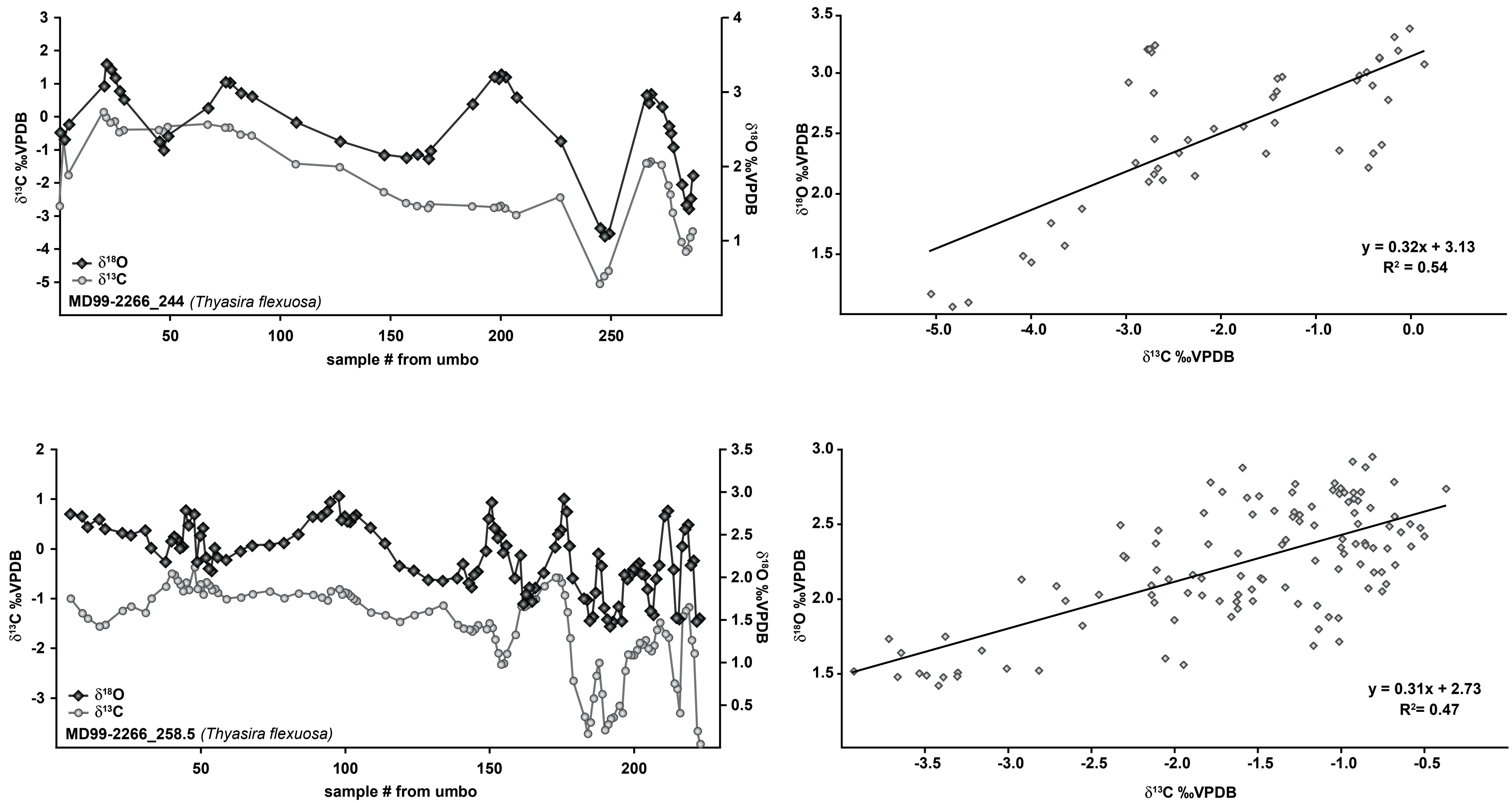


Fig. 2.6. $\delta^{13}C$ and $\delta^{18}O$ profiles (left) and correlation between $\delta^{13}C$ and $\delta^{18}O$ (right) of shell MD99-2266_244 (upper) and MD99-2266_258.5 (lower).

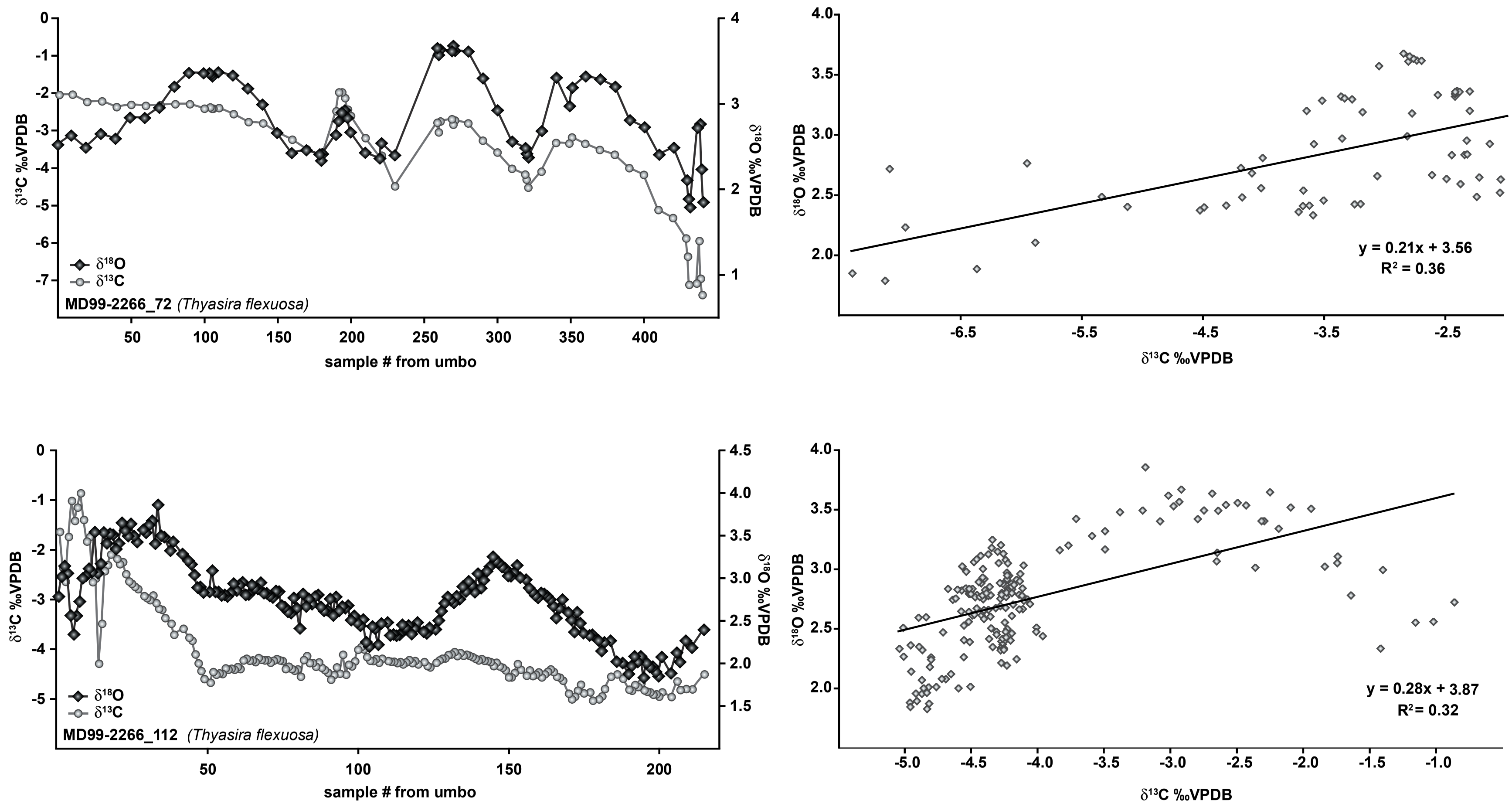


Fig. 2.7. $\delta^{13}C$ and $\delta^{18}O$ profiles (left) and correlation between $\delta^{13}C$ and $\delta^{18}O$ (right) of shell MD99-2266_72 (upper) and MD99-2266_112 (lower).

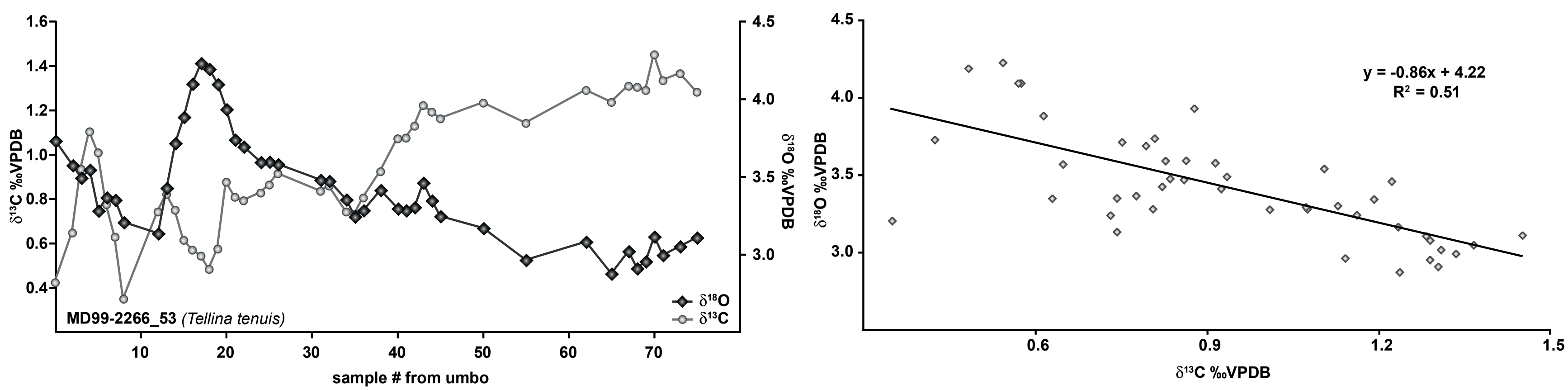


Fig. 2.8. $\delta^{13}C$ and $\delta^{18}O$ profiles (left) and correlation between $\delta^{13}C$ and $\delta^{18}O$ (right) of shell MD99-2266_53.

## .2.7 Discussion

### 2.7.1 360 BC to 240 BC

The earliest climate records dated 360 BC (Fig. 2.5) and 240 BC (Fig. 2.6) suggest that summer and winter temperatures were among the lowest of the entire record, with mean summer high temperatures of 6.0ºC and 5.1ºC, and mean winter low temperatures of 0.5ºC and 0ºC, respectively. A cool period at this time has been documented from other proxy data; Castaneda et al. (2004) note a cool period from 550 to 400 BC based on $\delta^{18}O$ values of benthic and planktonic foraminifera as well as total carbonate data in several cores from the north Iceland shelf, including B997-324 and B997-328, Knudsen and Eiriksson (2002) suggest cooling starting at 400 BC based on multiple sedimentological characteristics and foraminiferal distribution, and Andrews et al. (2001a) note a pronounced minimum in total carbonate at 350 BC in core B997-328.

This interval includes some of the lowest temperatures of our record. In one year of the 240 BC bivalve, the maximum annual temperature was only 4.1ºC, and in another year of growth the minimum annual temperature was -1.0ºC, the lowest of the entire record.

### 2.7.2 230 BC to AD 140

Following the notably cold interval of 360 to 240 BC, temperature increase abruptly at 230 BC (Fig. 2.7), with average maximum annual temperature increasing from 5.1ºC to 10.1ºC and average minimum annual temperature increase from 0.0ºC to 6.0ºC. The next record at 130 BC (Fig. 2.8) indicates a continued period of exceptional warmth. The highest annual temperature recorded is 12.9ºC, a full degree higher than any other maximum temperature of the entire record. The minimum annual temperatures are also remarkable; at 230 BC the average minimum temperature was 6.0ºC, and did not reach below 4.8ºC. The record at 110 BC (Fig. 2.9) shows a decrease in summer temperatures with the average highs of 7.2ºC, whereas winter temperatures remained virtually unchanged. In the next two records at AD 40 (Fig. 2.10) and AD 140 (Fig. 2.11), temperatures continue to decrease, down to 7.6ºC for the average summer high and 2.9ºC for the average winter low.

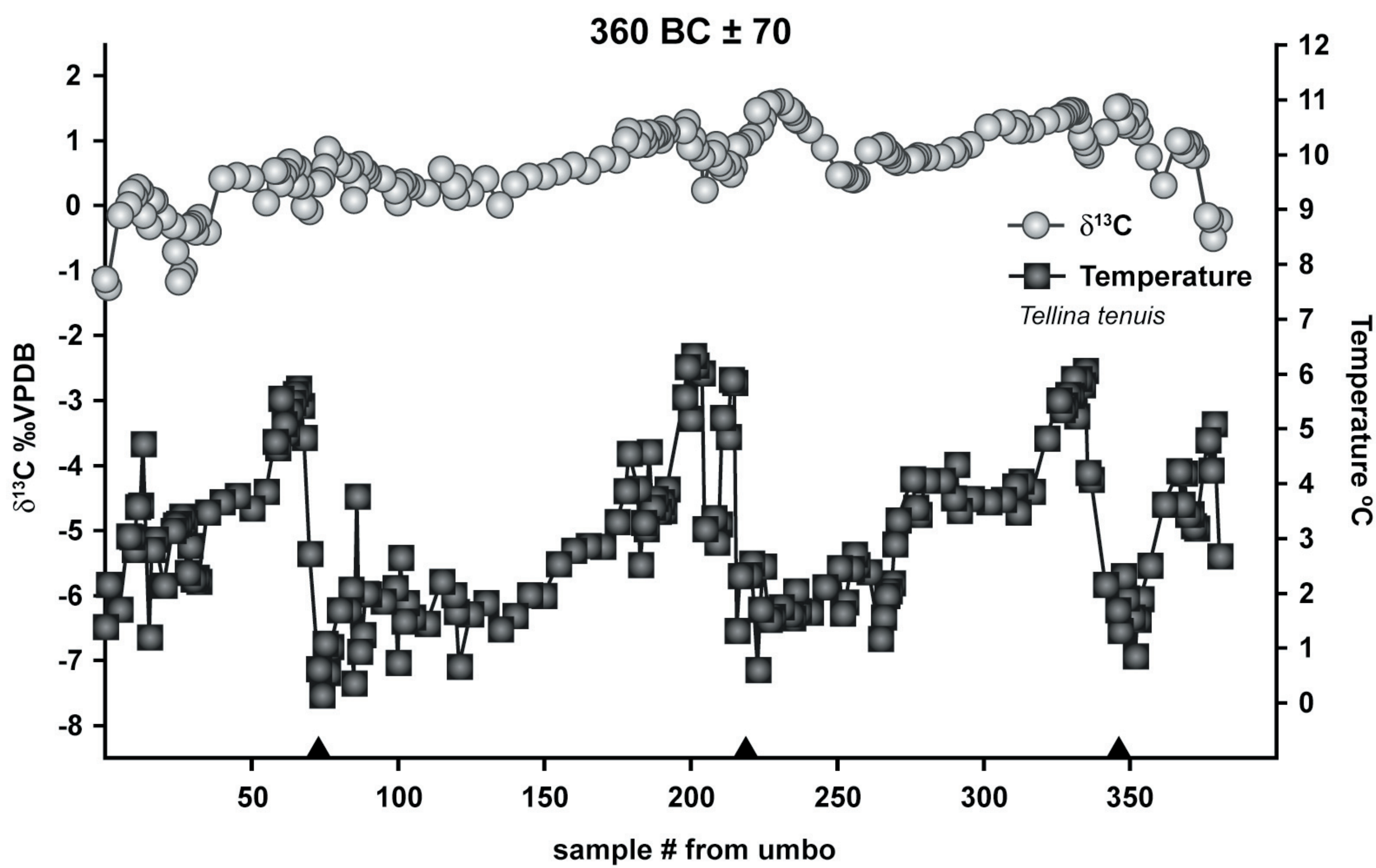


Fig. 2.9. $\delta^{13}C$ values and reconstructed temperatures of shell B997-328/248.75-257.25 cm, c. 360 BC. Arrows along the horizontal axis indicate the position of annual external growth lines.

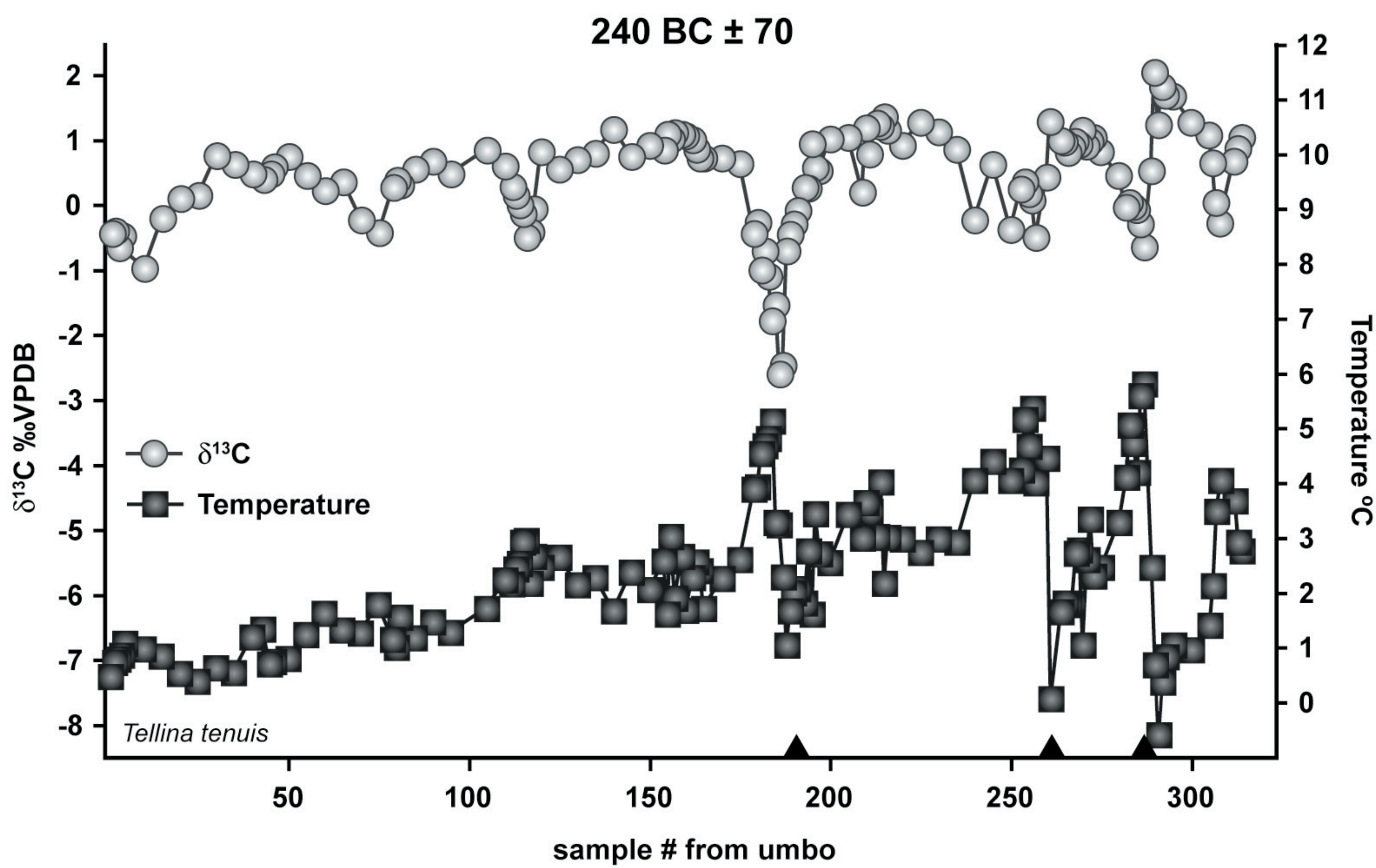


Fig. 2.10. $\delta^{13}C$ values and reconstructed temperatures of shell B997-328/238.5-241.25 cm, c. 240 BC. Arrows along the horizontal axis indicate the position of annual external growth lines.

This interval in our series occurs during the Roman Warm Period (RWP), c. 250 BC to AD 450 (Desprat et al., 2003) characterized by proxy climate and historical records as a period of widespread warmth and dryness across Western Europe (Lamb, 1995). In Iceland, peak temperatures occurred from 230 to 130 BC, and both summer and winter temperatures were exceptionally high.

### 2.7.3 AD 410

At AD 410 (Fig. 2.12) both summer and winter temperatures decrease, nearly to pre-RWP temperatures, with an average maximum temperature of 5.3ºC, and an average minimum temperature of 0.9ºC. The second coldest minimum temperature of the entire record (0.5ºC) is recorded at this time. This cool period was also noted by Stotter et al. (1999), who describe a cold period around AD 450 in Iceland based on the maximum advance of continental glaciers determined from radiometrically and tephrochronologically dated moraines. Andresen et al. (2005) also find evidence of a cooler climate in Iceland at this time, based on petrologic indicators from a northwest shelf that suggest a period of increased storminess and/or increased ice rafted debris caused by greater advection of polar waters on the northern shelf around AD 450 (Andresen et al., 2005). As well, pollen records from northern Iceland document the disappearance of *Betula* sp. (birch) pollen by AD 450, likely indicating a decrease in summer temperatures (Andrews et al., 2001b). The climate records from Iceland also agree with the central Greenland ice core (Crête), that suggests a colder regime beginning around AD 400 (Dansgaard et al., 1975). In Europe, the period c. AD 400 to 600 has been called the “Dark Ages Cold Period” (Nyberg et al., 2002), an interval of cool and wet conditions across much of Western Europe.

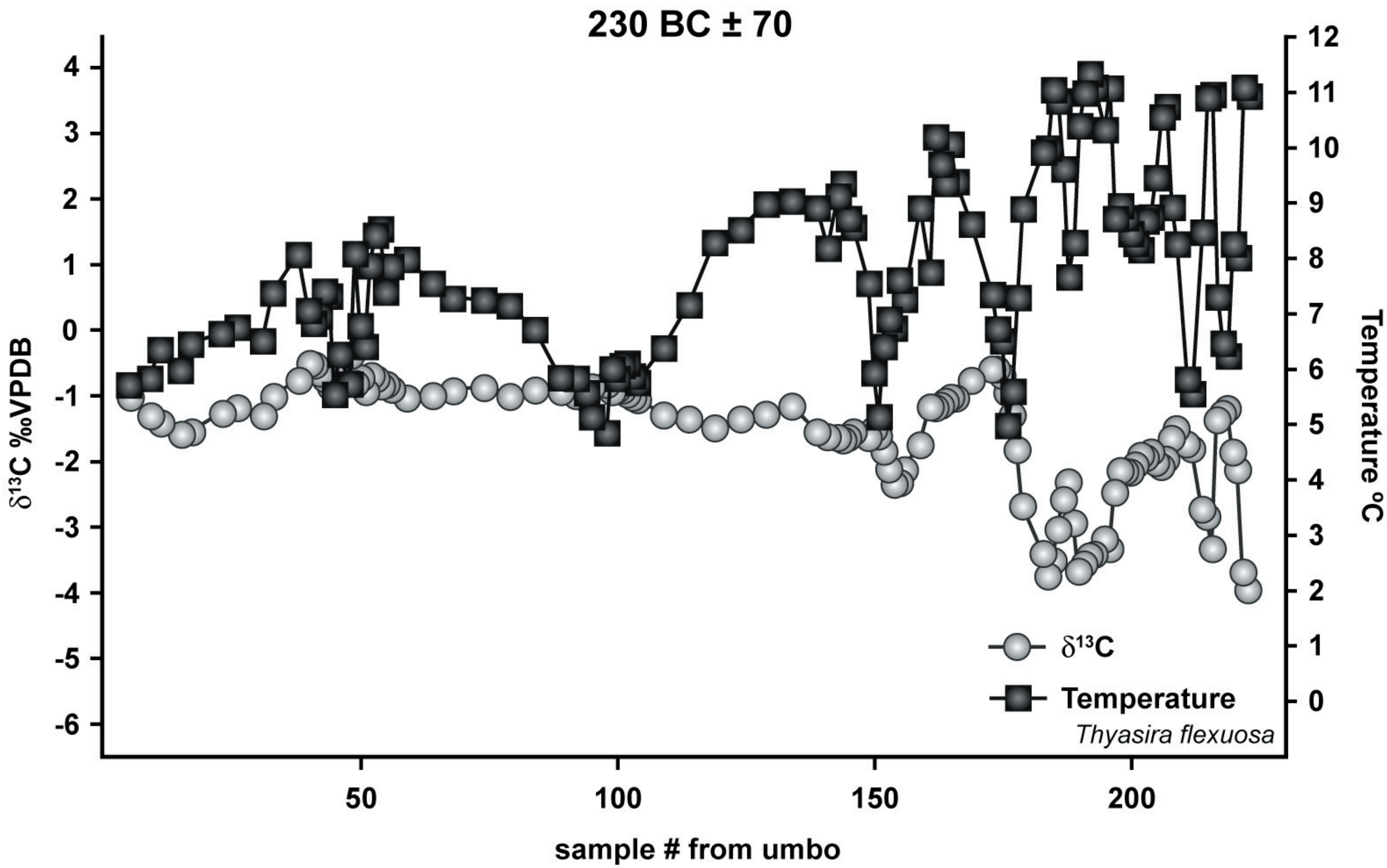


Fig. 2.11. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/258.5-259.5 cm, c. 230 BC.

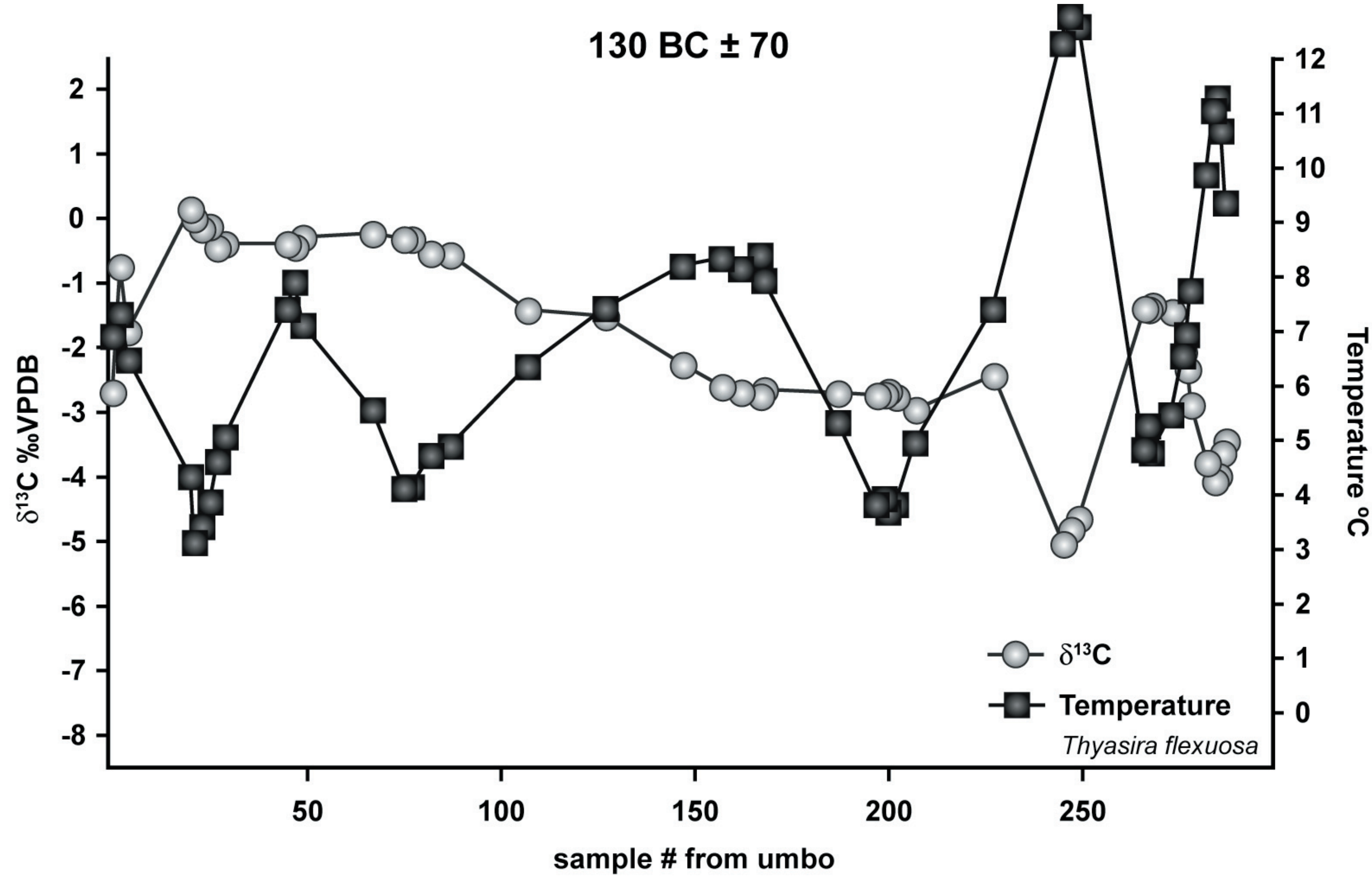


Fig. 2.12. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/244-245.5 cm, c. 130 BC.

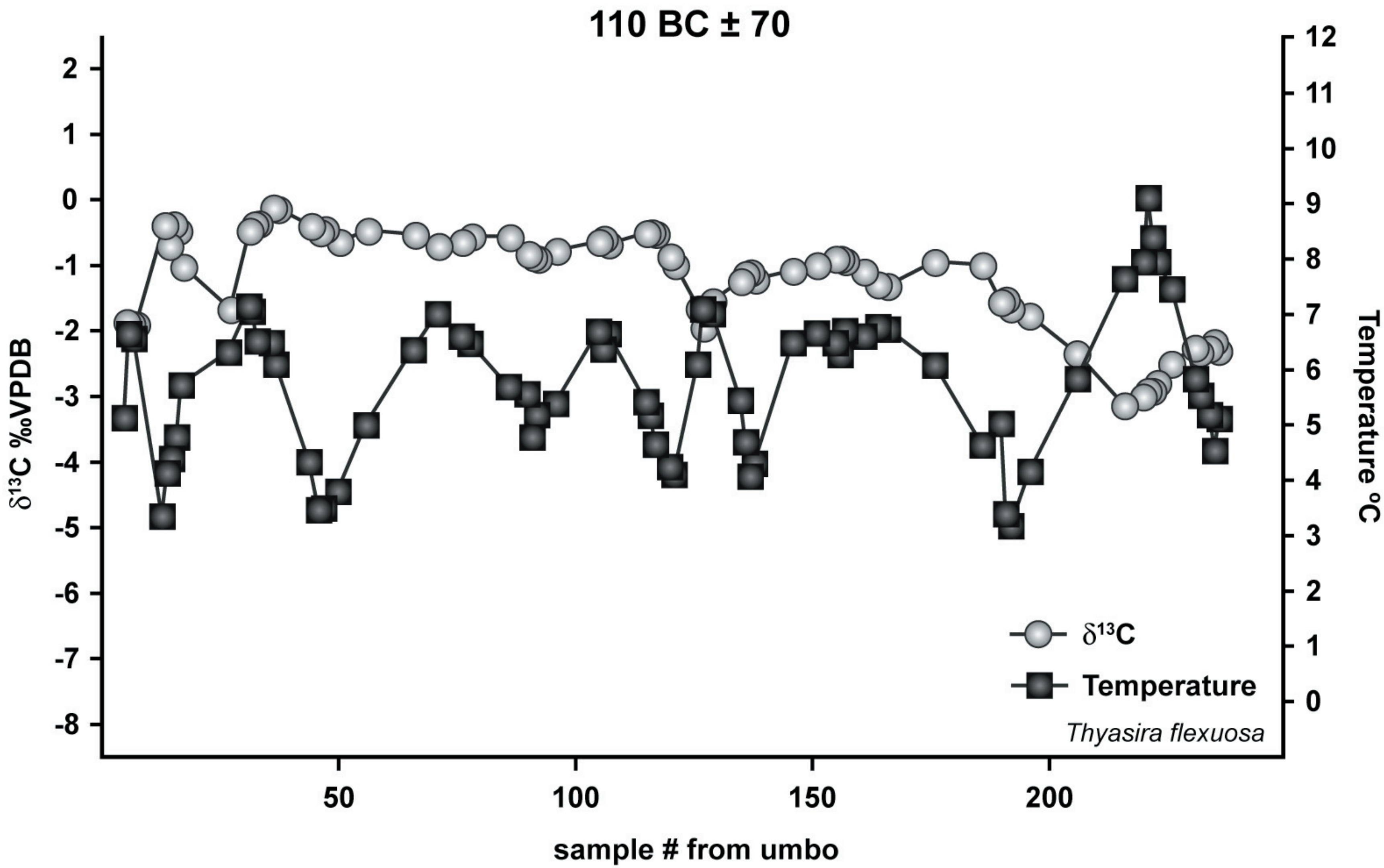


Fig. 2.13. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/241-243cm, c. 110 BC.

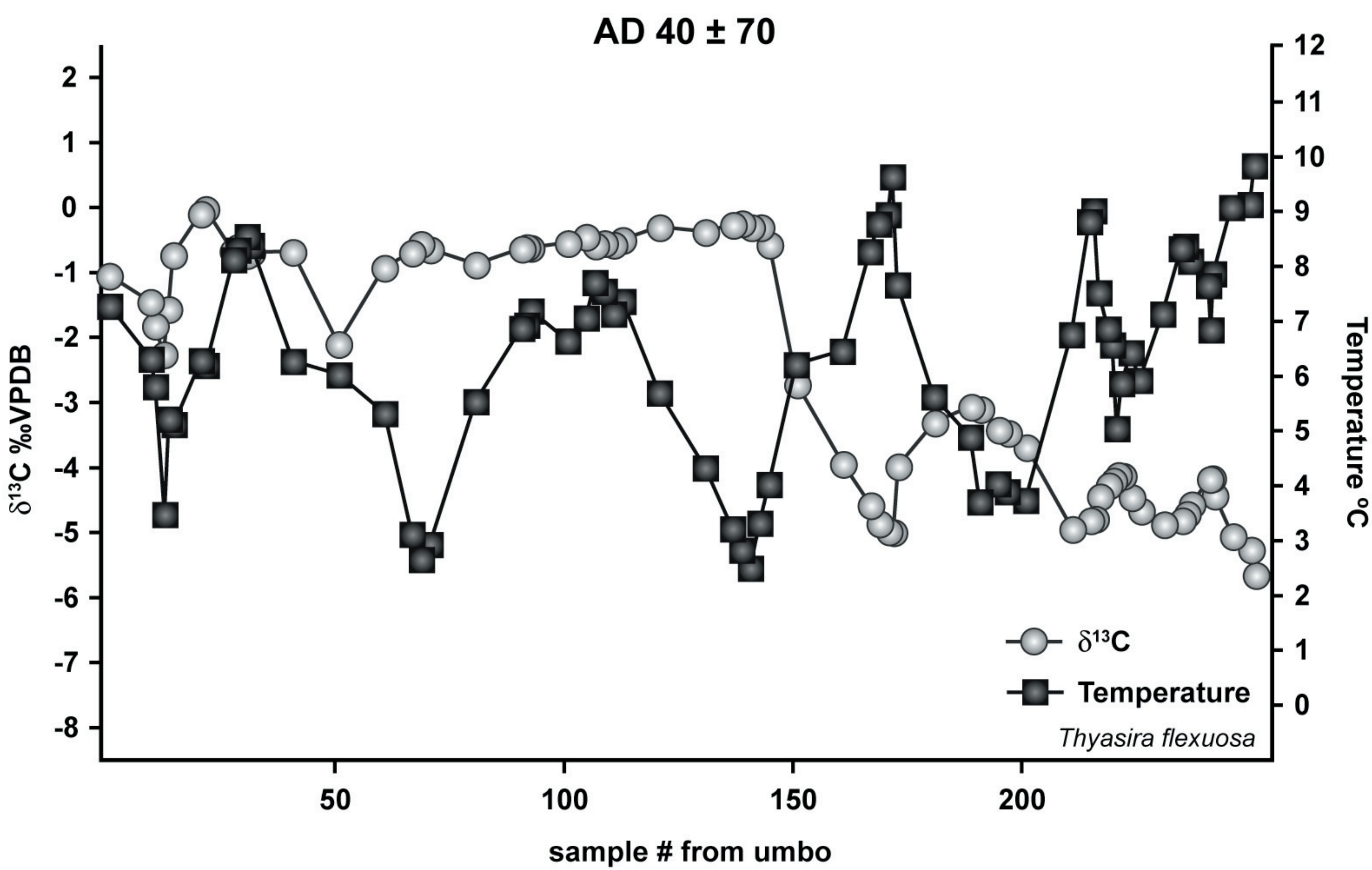


Fig. 2.14. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/222cm, c. AD 40.

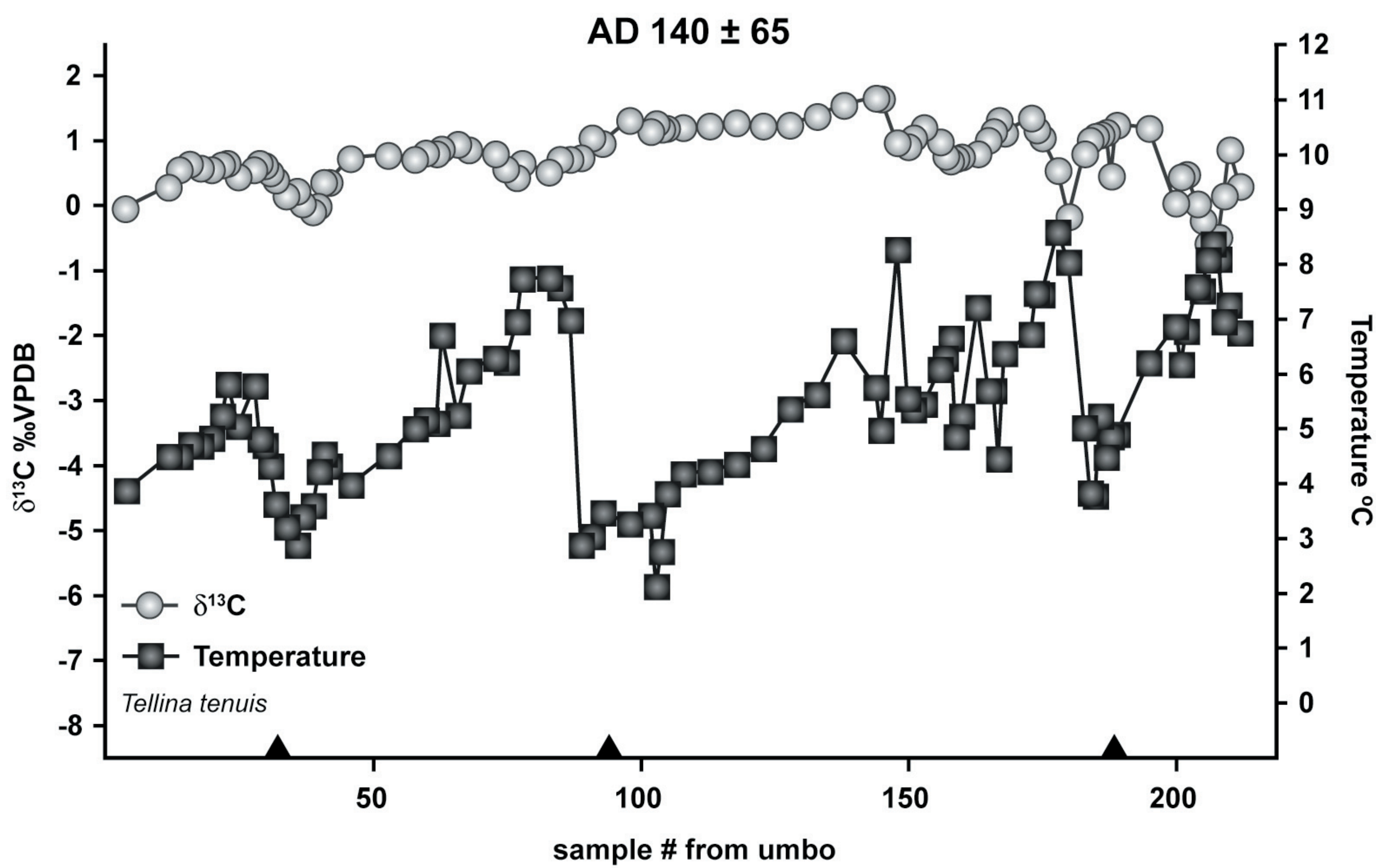


Fig. 2.15. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/208-209 cm, c. AD 140. Arrows along the horizontal axis indicate the position of annual external growth lines.

### 2.7.4 AD 470 to 760

The next series of climate profiles suggests a return to warmer conditions, beginning at AD 470 and peaking at AD 640 (Fig. 2.13-2.16), at which time average maximum annual temperature is the highest of the entire 2000-yr record at 11.3ºC, and average minimum annual temperature is 5.7ºC, the second highest of the entire record. One of the records at AD 640 (Fig. 2.16) is also notable for the consistency of warm temperatures. One of the bivalves records the highest sustained annual temperatures--four summers above 10.5ºC, far surpassing any other of the climate profiles. The minimum annual temperatures are also consistently high in this bivalve; they are all 4.9ºC or higher. This peak in temperatures is followed by a decrease in temperatures at AD 680 (Fig. 2.17), but they increase again at AD 760 (Fig. 2.18).

During this interval, winter temperatures show a higher degree of variability than summer temperatures, especially at AD 680 and 760, with range of 3.6ºC and 1.8ºC for winter compared to 1.1ºC and 0.5ºC for summer, respectively.

The interval of peak medieval warmth in our record is between AD 610 and 760. Although this warming is in agreement with the central Greenland ice core (Dansgaard et al., 1975), it is earlier than the peak warmth experienced in Western Europe, where most proxy climate records indicate the onset of peak warmth during the Medieval Warm Period at c. AD 800 to 850 (Lamb, 1979).

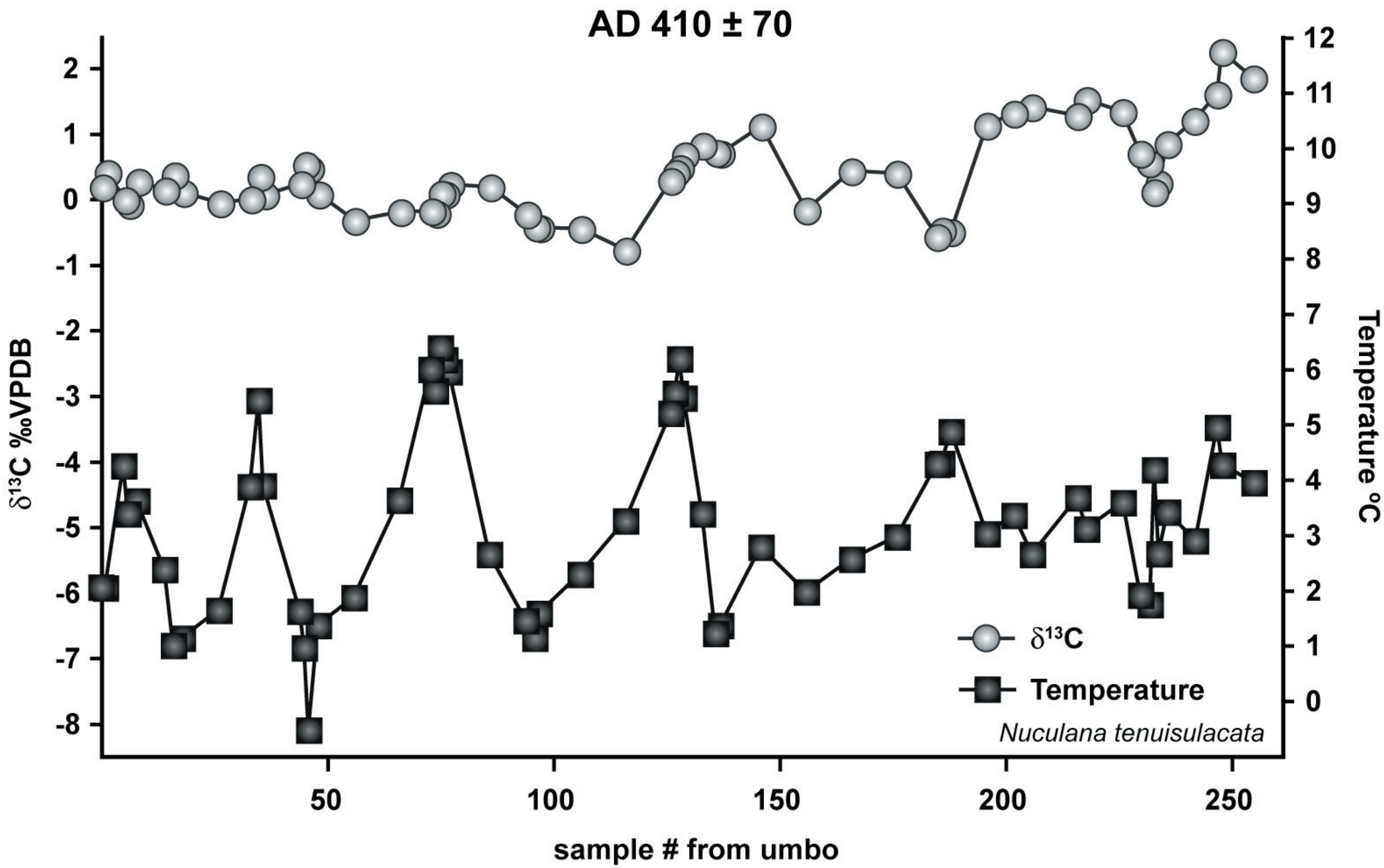


Fig. 2.16. $\delta^{13}C$ values and reconstructed temperatures of shell B997-328/168.75-171.25 cm, c. AD 410.

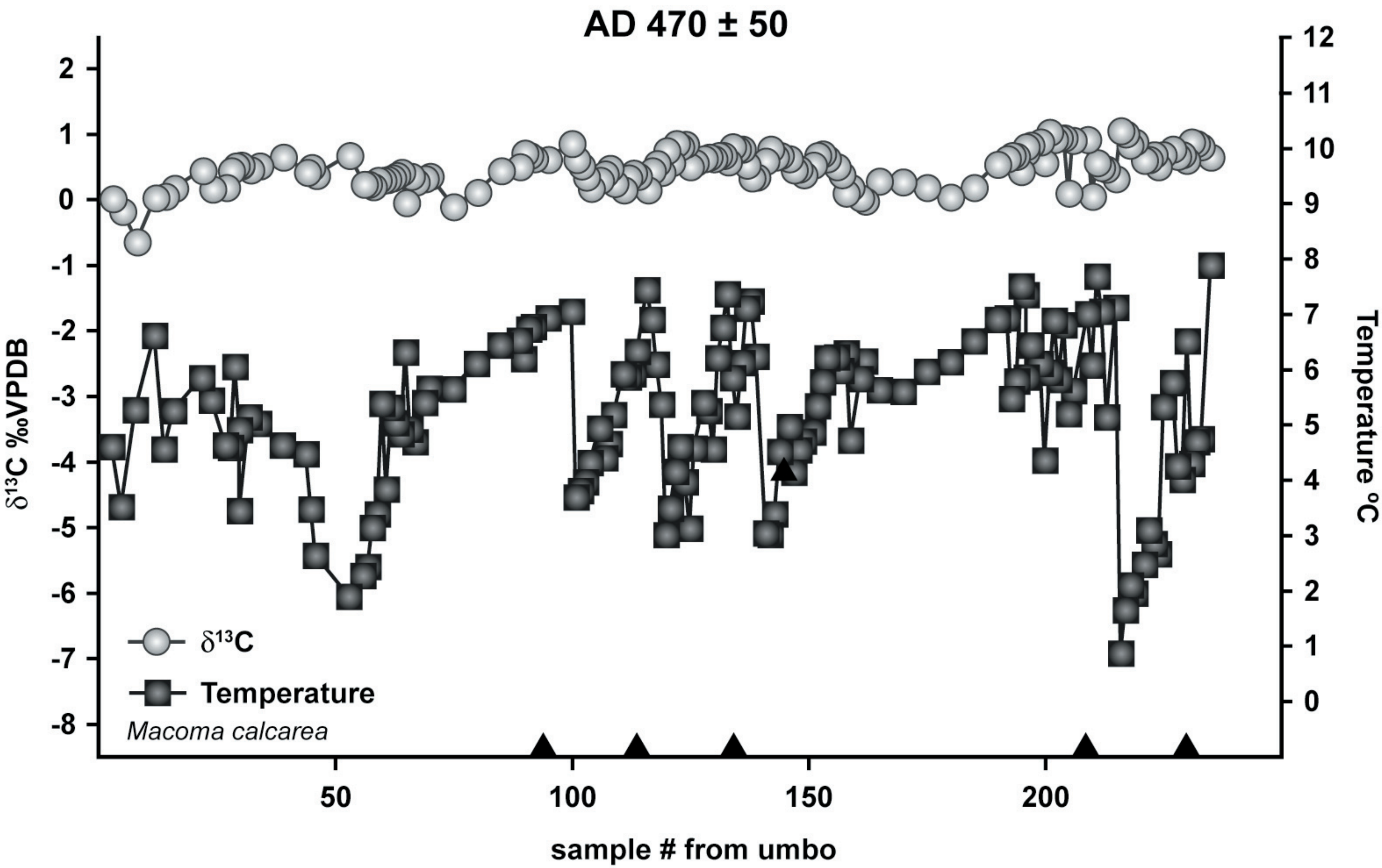


Fig. 2.17. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/174.5-175.5 cm, c. AD 470. Arrows along the horizontal axis indicate the position of annual external growth lines.

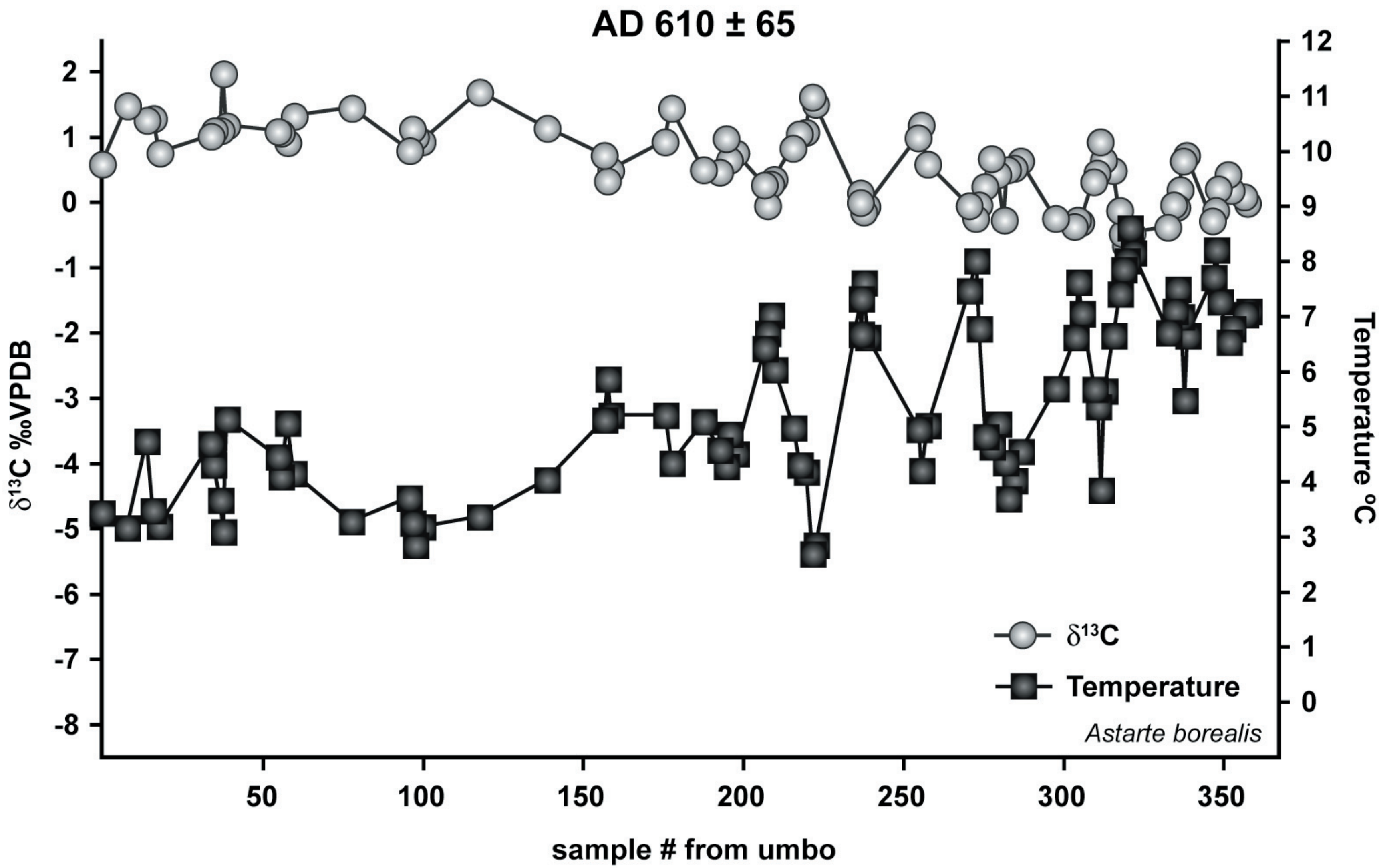


Fig. 2.18. $\delta^{13}C$ values and reconstructed temperatures of shell B997-324/30-32 cm, c. AD 610.

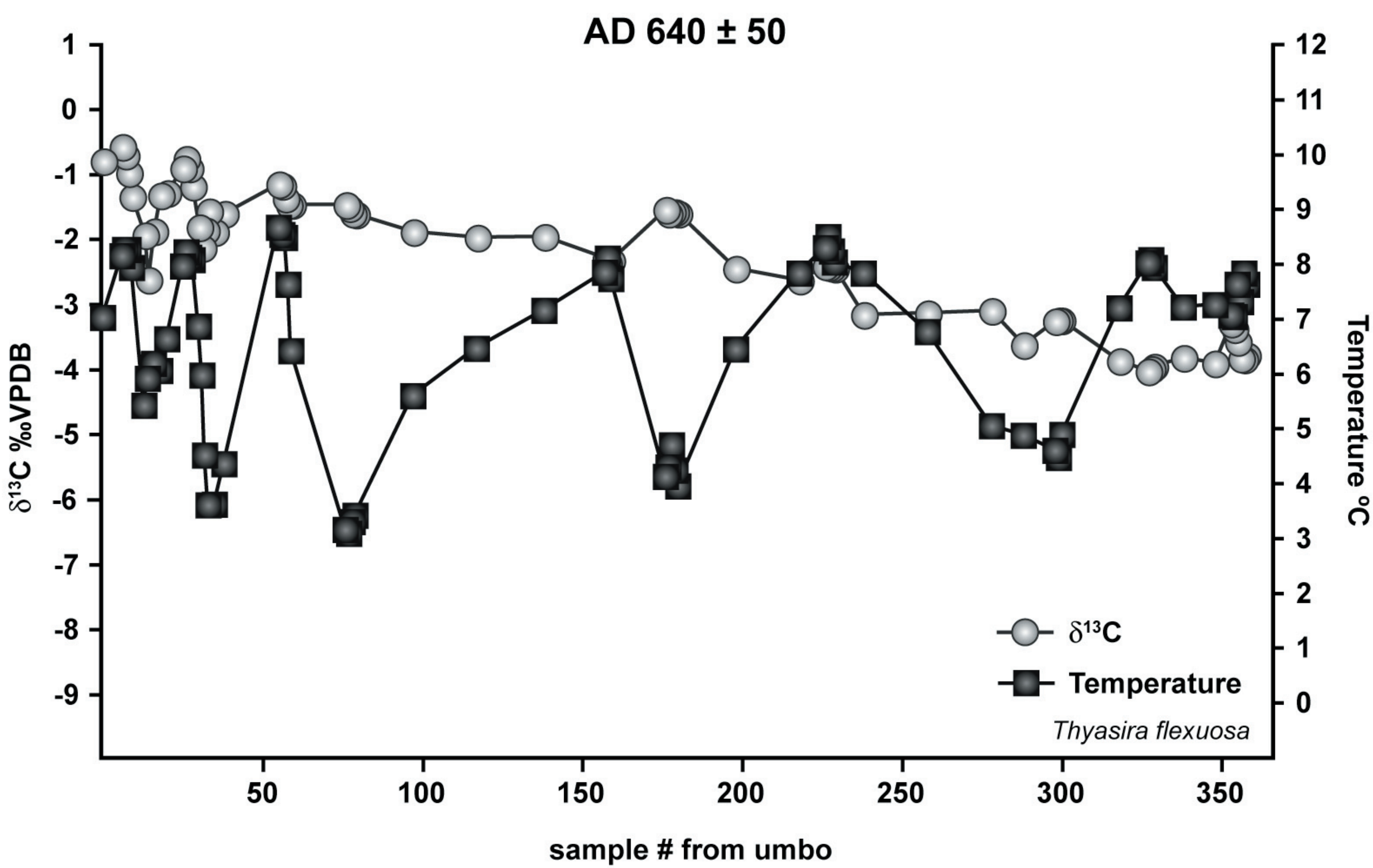


Fig. 2.119. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/157-159 cm, c. AD 640.

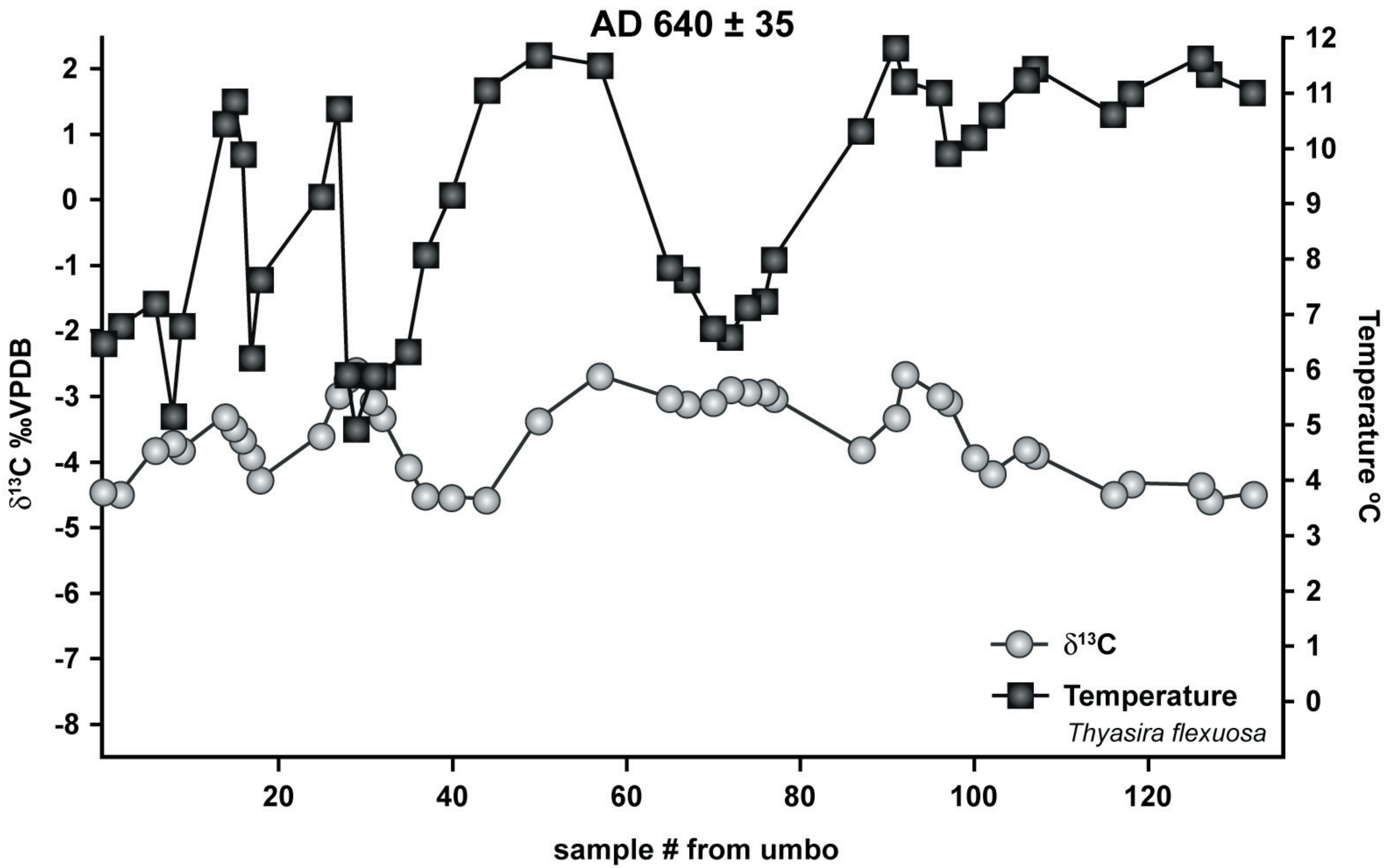


Fig. 2.20. $\delta^{13}C$ values and reconstructed temperatures of shell B997-341/91.75 cm, c. AD 640.

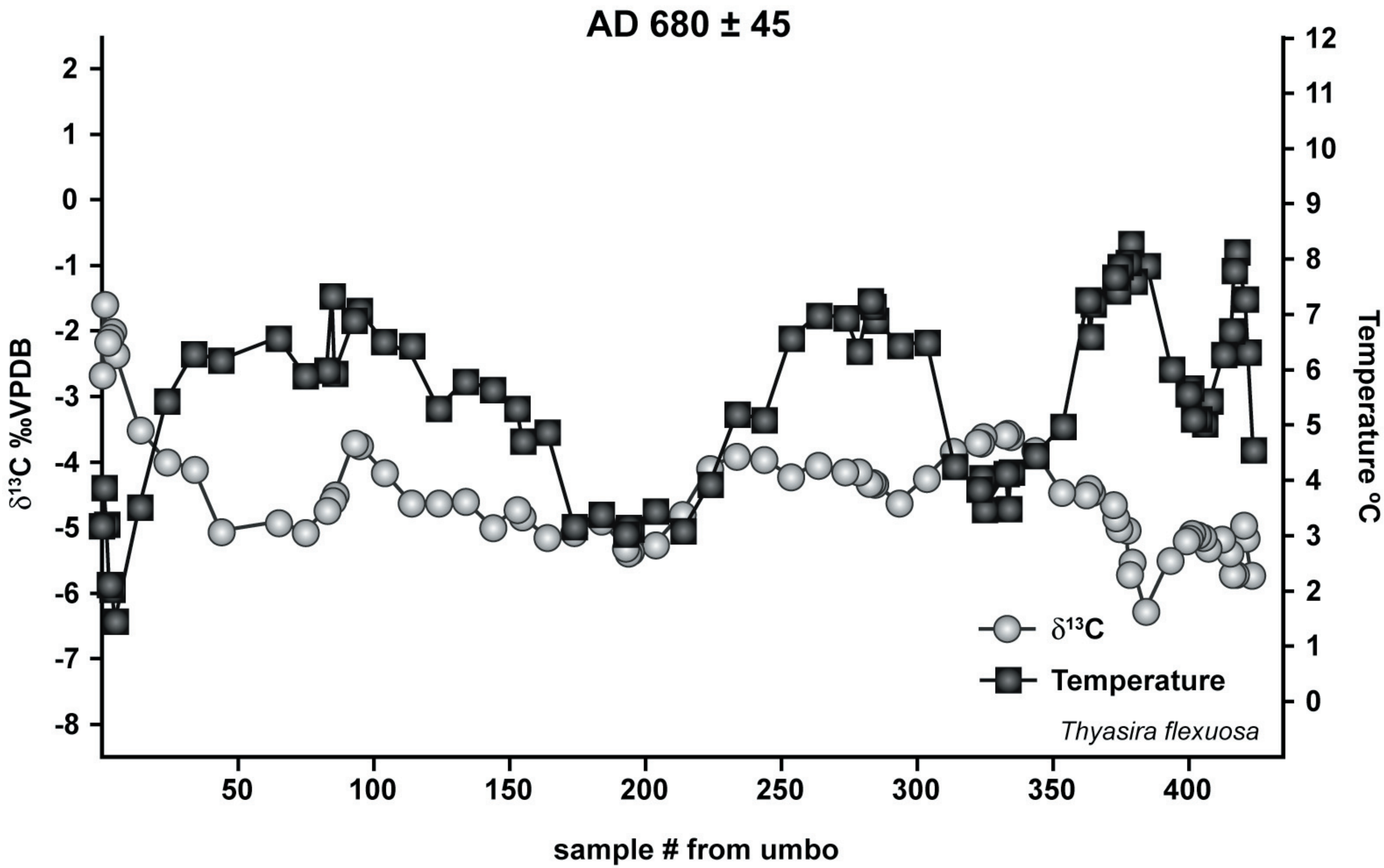


Fig. 2.21. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/150-151.5 cm, c. AD 680.

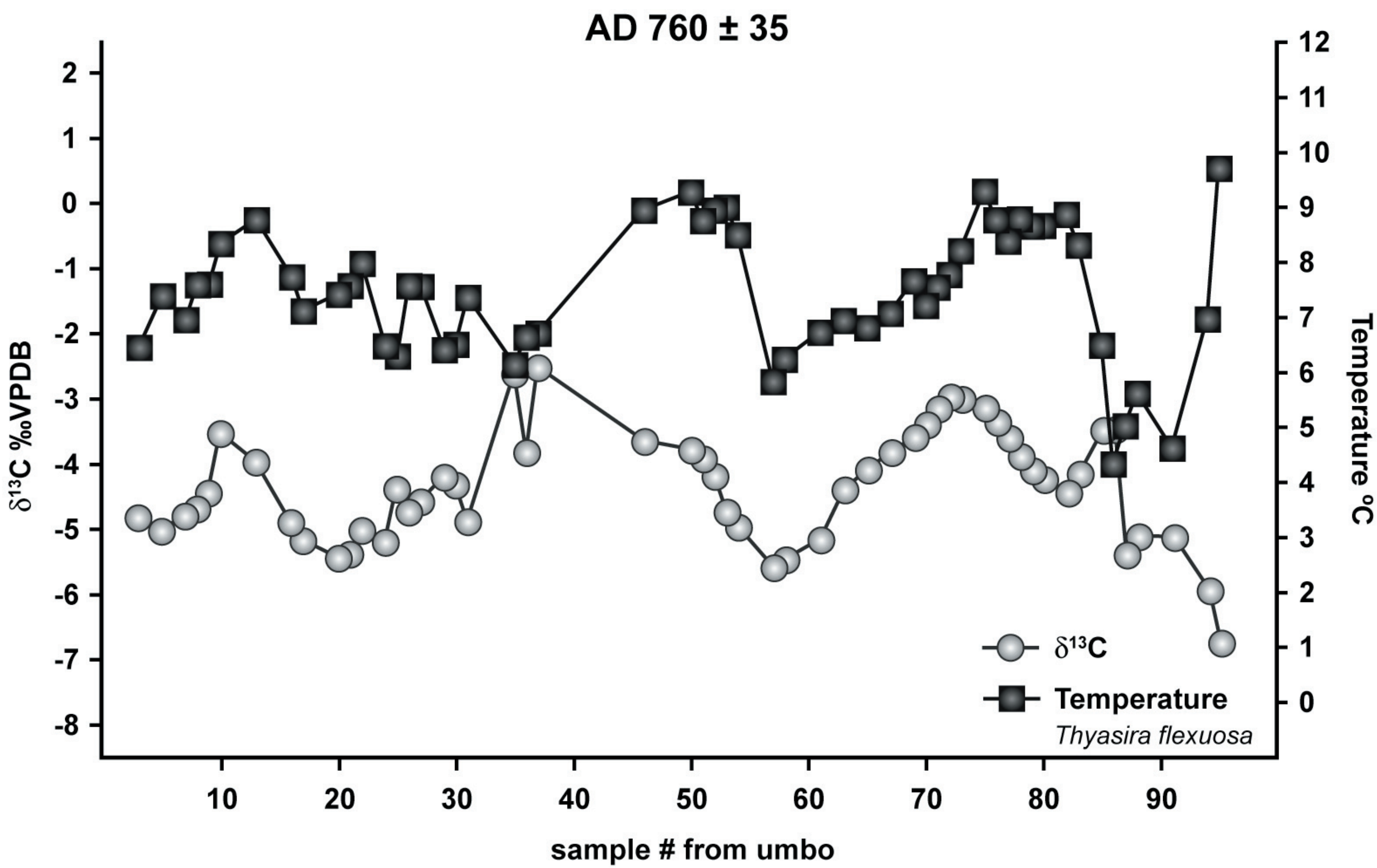


Fig. 2.22. $\delta^{13}C$ values and reconstructed temperatures of shell B997-341/66.25 cm, c. AD 760.

### 2.7.5 AD 960 to 1320

Settlement of Iceland by Norwegian settlers is thought to have begun c. AD 874, although there is some evidence that Irish monks had been living in Iceland for an indeterminate period prior (Karlsson, 2000). Sea voyages of Vikings and the subsequent settlement of Iceland and Greenland (c. 984), as well as journeys to North America (c. AD 985-1000), have often been interpreted as circumstantial evidence for warm conditions in the North Atlantic region. Our record supports this hypothesis, at least for the period before and immediately after settlement.

Iceland has a remarkably rich documentary history (Ogilvie and Jonsson, 2001), and historical documents have been used by several authors to reconstruct climatic conditions in Iceland (e.g. Koch, 1945; Bergthorsson, 1969; Ogilvie, 1991). Some of the earliest references to severe climatic conditions are from *Landnamabok* (Book of Settlements) that describes the colonizers of Iceland (Ogilvie, 1991a). The *Landnamabok* describes a "great dearth winter", or famine, that occurred c.AD 975-976. During this dearth,

> "…there was a great famine-winter in Iceland in heathen days, the severest there has been in Iceland. Men ate ravens then and foxes, and many abominable things were eaten which ought not to be eaten, and some had the old and helpless killed and thrown over the cliffs"

Another famine is recorded as occurring in the winter of AD 1055-1056 (Ogilvie, 1991a). The production of crops in Iceland is particularly sensitive to small (~1.5ºC) variations in the average temperature of the growing season (Bryson, 1974). Survival of livestock through the winter is dependent on having enough fodder (Vesteinsson et al., 2002), such that a series of cool growing seasons could be disastrous. The low peak summer temperatures at AD 990, 1080, and 1120 suggest that crop production would be severely curtailed. This phase in the record occurs during the "Medieval Warm Period", a time of generally warmer climatic conditions experienced in many parts of the world, from about AD 900 to AD 1300 (Lamb, 1965). This term has been criticized (Ogilvie and Jonsson, 2001) for being poorly defined and overly general, but remains in widespread usage. However, the MWP is now understood as a period of climatic anomalies, where many areas experienced overall warmer climates, although not constantly throughout the entire period (Soon and Baliunas, 2003). The Icelandic record reflects this variability, with a cooler temperatures recorded at AD 1080 and 1120. In other parts of Europe, there is other climate proxy evidence of cooling at these times. Pfister et al. (1998) found that winter air temperatures in western central Europe from AD 1090 to 1179 were as cold as those that

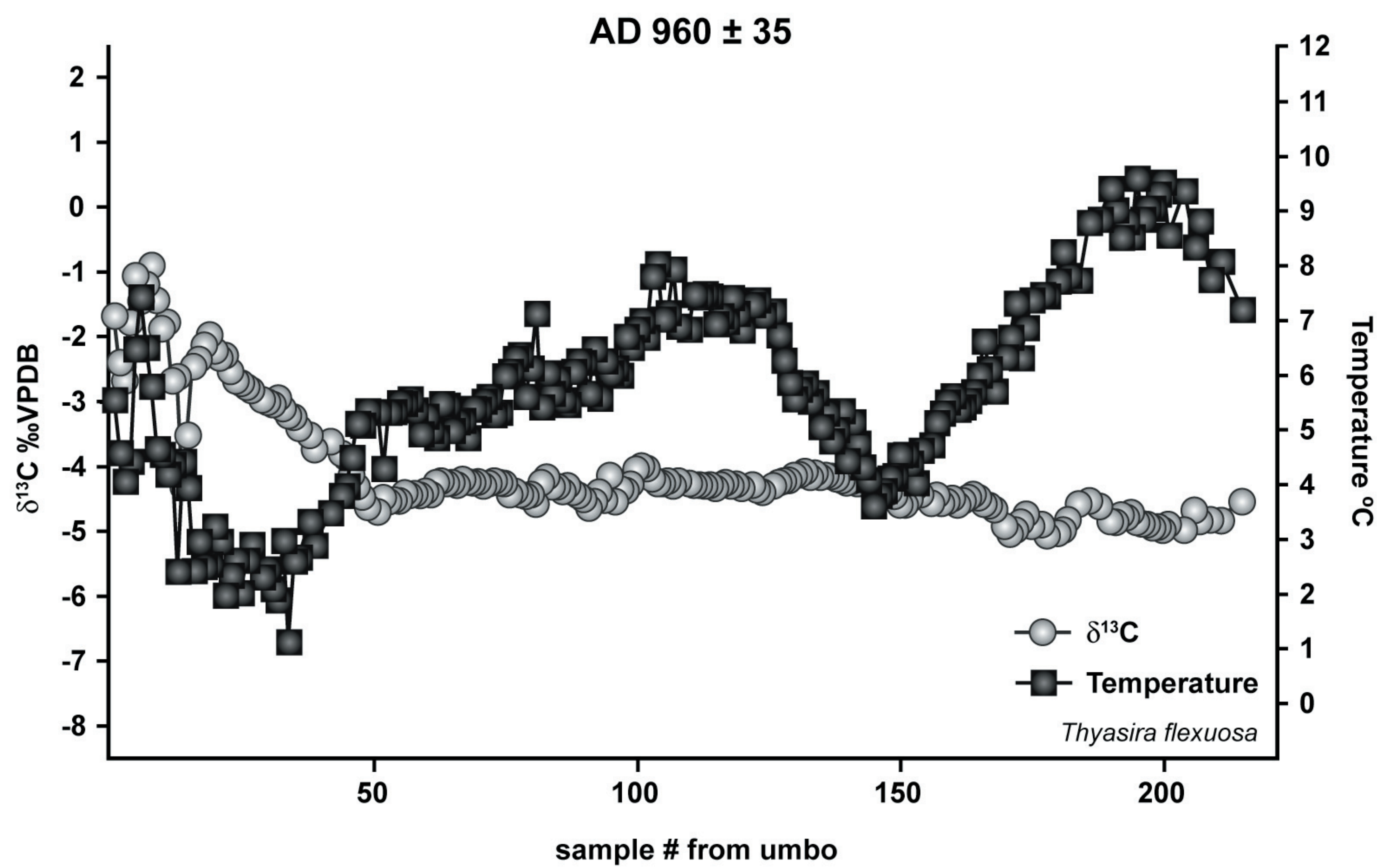


Fig. 2.23. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/112-113.5 cm, c. AD 960.

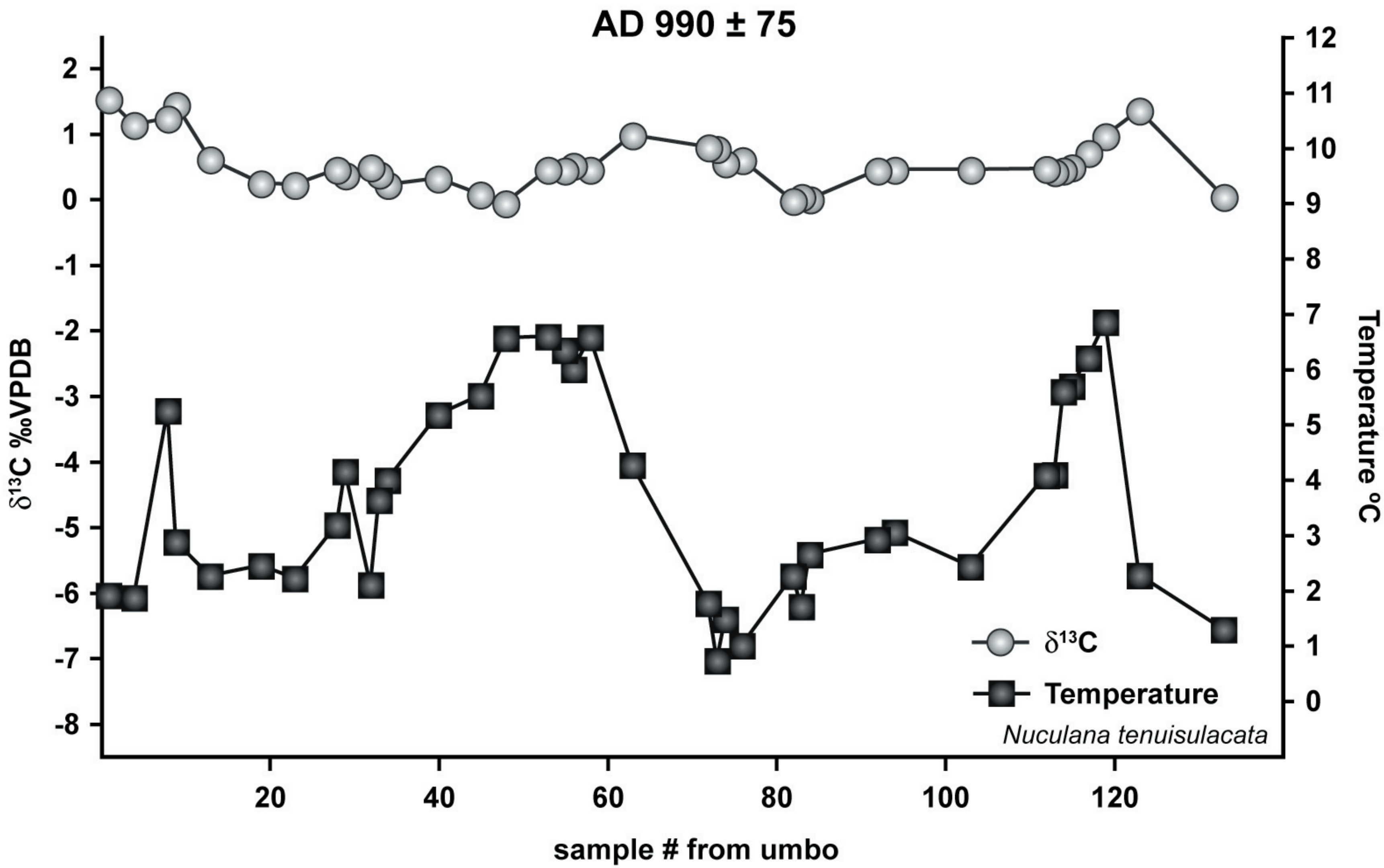


Fig. 2.24. $\delta^{13}C$ values and reconstructed temperatures of shell B997-341/56 cm, c. AD 990.

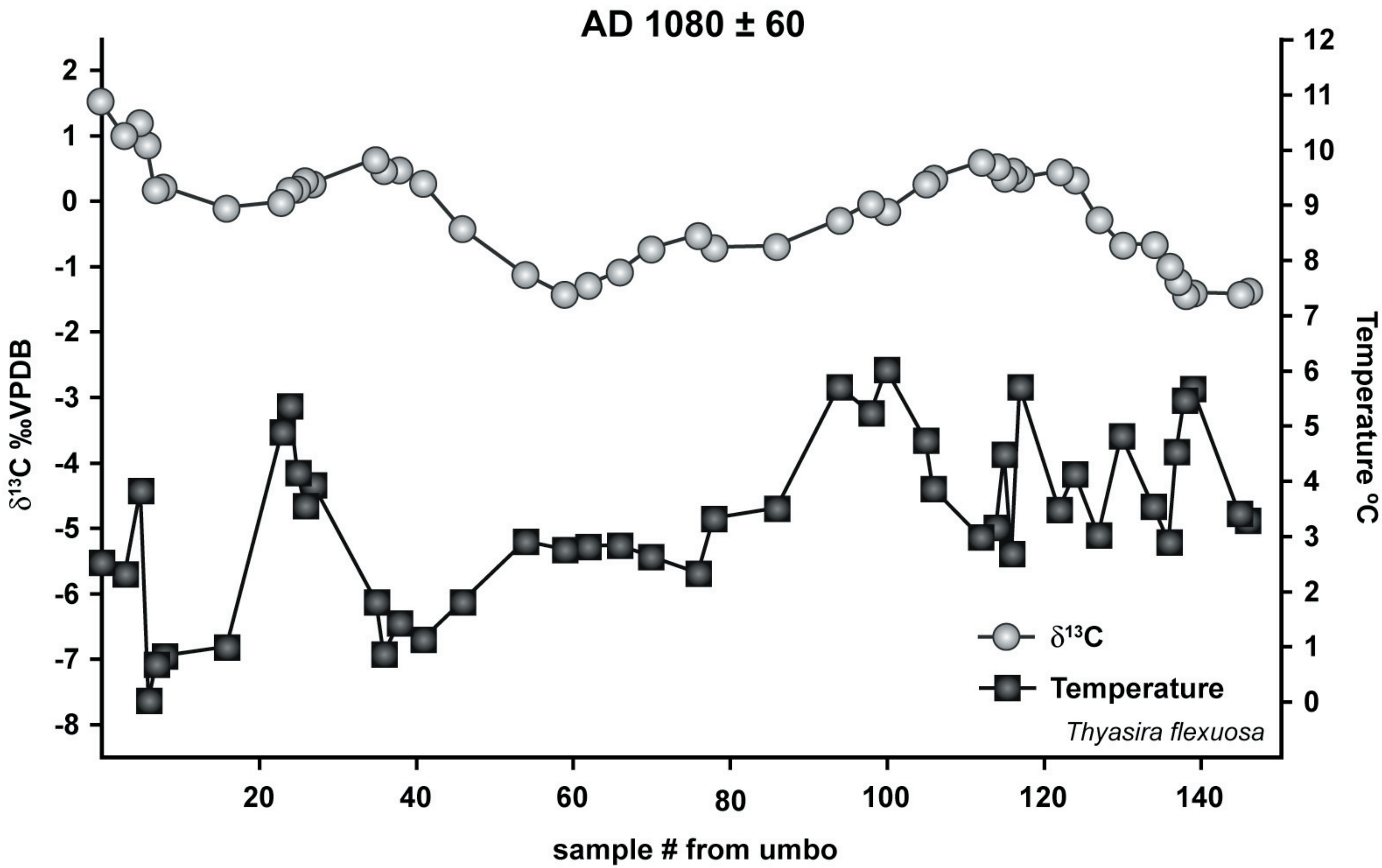


Fig. 2.25. $\delta^{13}C$ values and reconstructed temperatures of shell B997-328/100-101.25 cm, c. AD 1080.

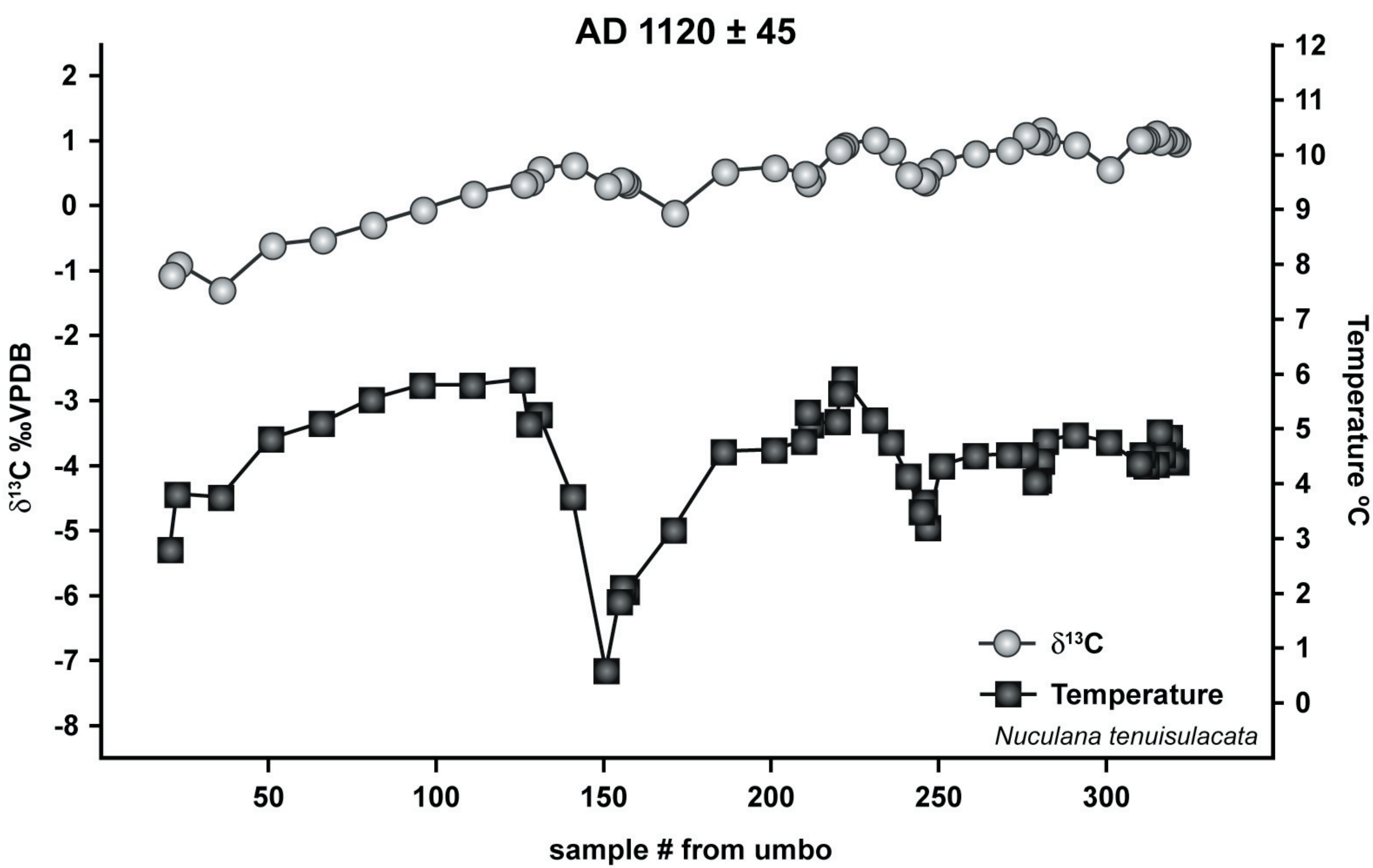


Fig. 2.26. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/90-92 cm, c. AD 1120.

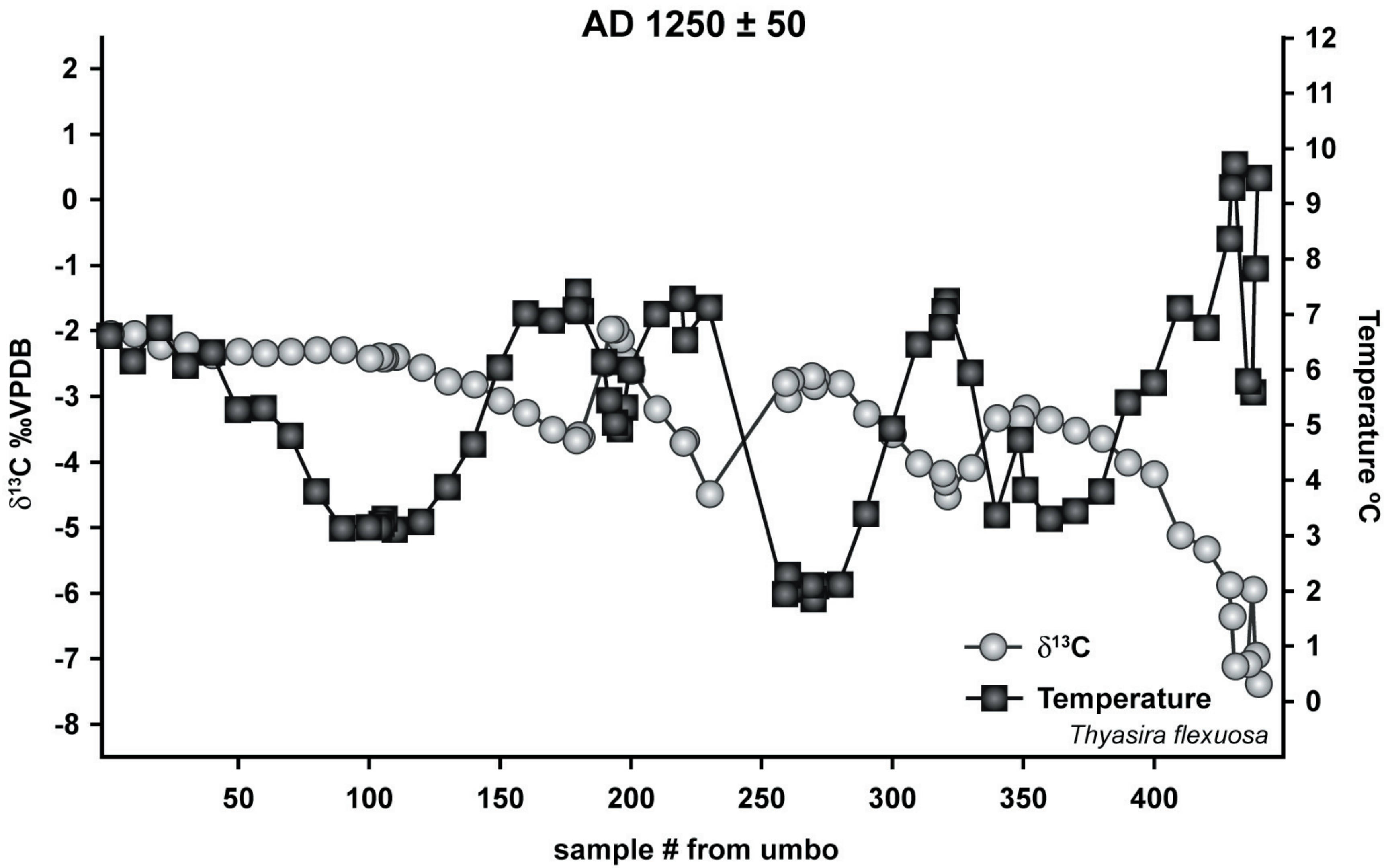


Fig. 2.27. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/72-74 cm, c. AD 1250.

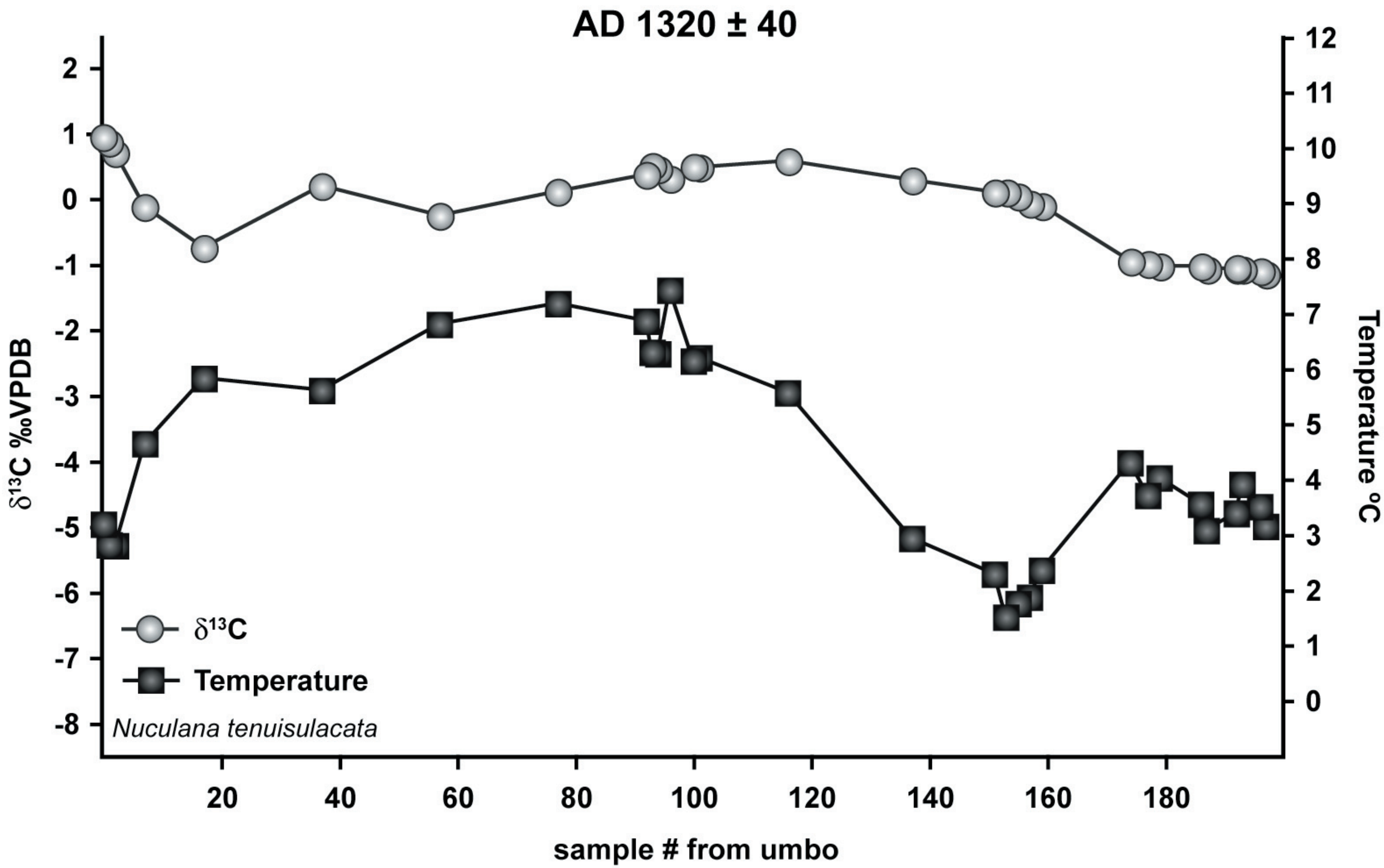


Fig. 2.28. $\delta^{13}C$ values and reconstructed temperatures of shell B997-341/35.25 cm, c. AD 1320.

occurred during the Little Ice Age, based on documentary sources. Evidence from glacier moraines indicates that the MWP in northern Europe was interrupted by a glacial expansion from about AD 1050 to 1150 (Grove and Switsur, 1994).

The period AD 960 to 1320 (Fig. 2.19-2.24) is notable in our record as a time of greater year-to-year variability than any other time, and records especially high variability in winter temperatures than any other period examined. This is in agreement with the historical sources available from the late twelfth/early thirteenth century, that describe alternating intervals of harsh climate c. AD 1180 to 1210, no severe weather mentioned between AD 1211 to 1232, then sporadic references to severe weather, with both cold and mild seasons reported up to AD 1325 (Ogilvie, 1991a).

### 2.7.6 AD 1380 to 1660

The first record of this interval at AD 1380 (Fig. 2.25) represents the coldest average maximum and minimum temperatures of the entire 2000-yr period, at 4.6ºC and -0.4ºC, respectively, likely characterizing the onset of the "Little Ice Age". Although the bivalve at AD 1380 lived only one winter, the next one at AD 1420 (Fig. 2.26) records the lowest series of temperatures – four consecutive winters all 1.6ºC or lower, and the following bivalve at AD 1550 (Fig. 2.27) records three consecutive winters at 1.6ºC or lower. The summer temperatures are also cool, but not exceptionally so. This suggests that the Little Ice Age period was characterized more by cold winters than cold summers.

The youngest bivalves in our series, both dated AD 1660 (Fig. 2.29 and 2.30), have contrasting records. One records temperatures similar to preceding records, whereas the other records warmer temperatures. In particular, the minimum temperatures are particularly high, averaging 5.5ºC.

This characterizes a period of greater variability in Icelandic climate that has also been indicated by the documentary record. Historical documents suggest that the early and late decades of the 17$^{th}$ century were cool, but there is a notable period of mild climate from c. AD 1640 to 1690 during which there is almost no mention of sea-ice (Ogilvie, 1991).

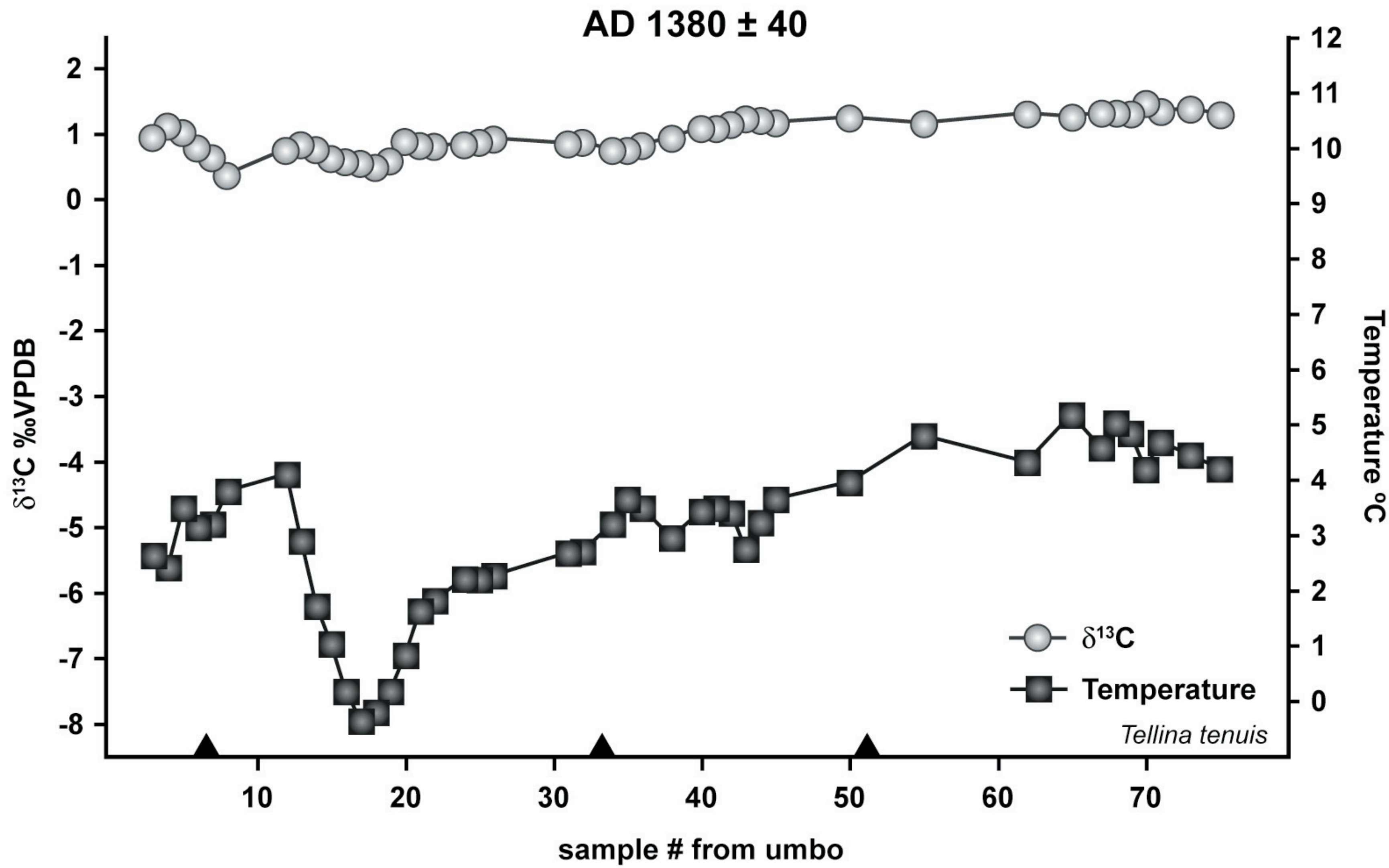


Fig.2.29. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/53 cm, c. AD 1380. Arrows along the horizontal axis indicate the position of annual external growth lines.

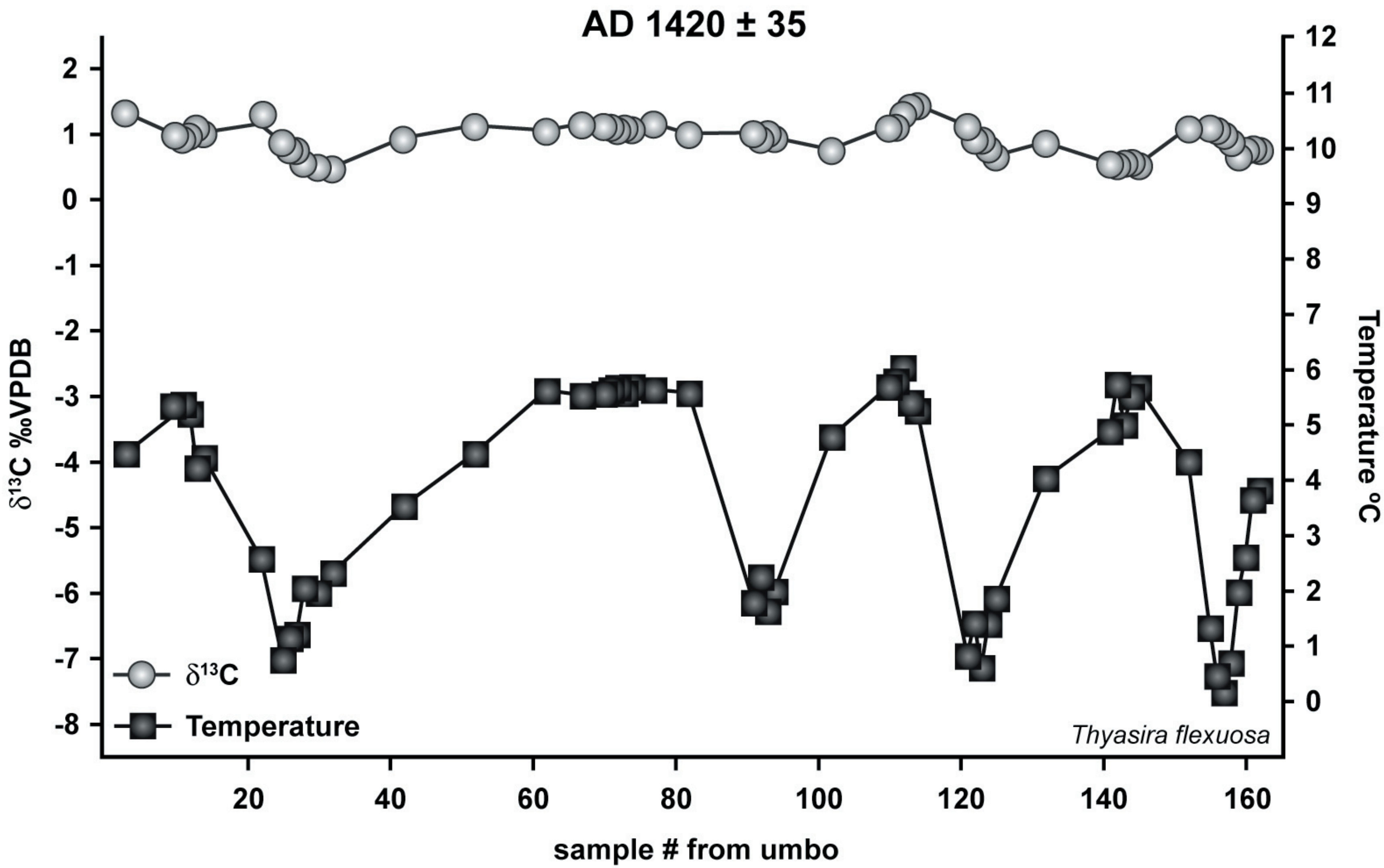


Fig. 2.2.30. δ$^{13}$C values and reconstructed temperatures of shell MD99-2266/46.5-47.5 cm, c. AD 1420.

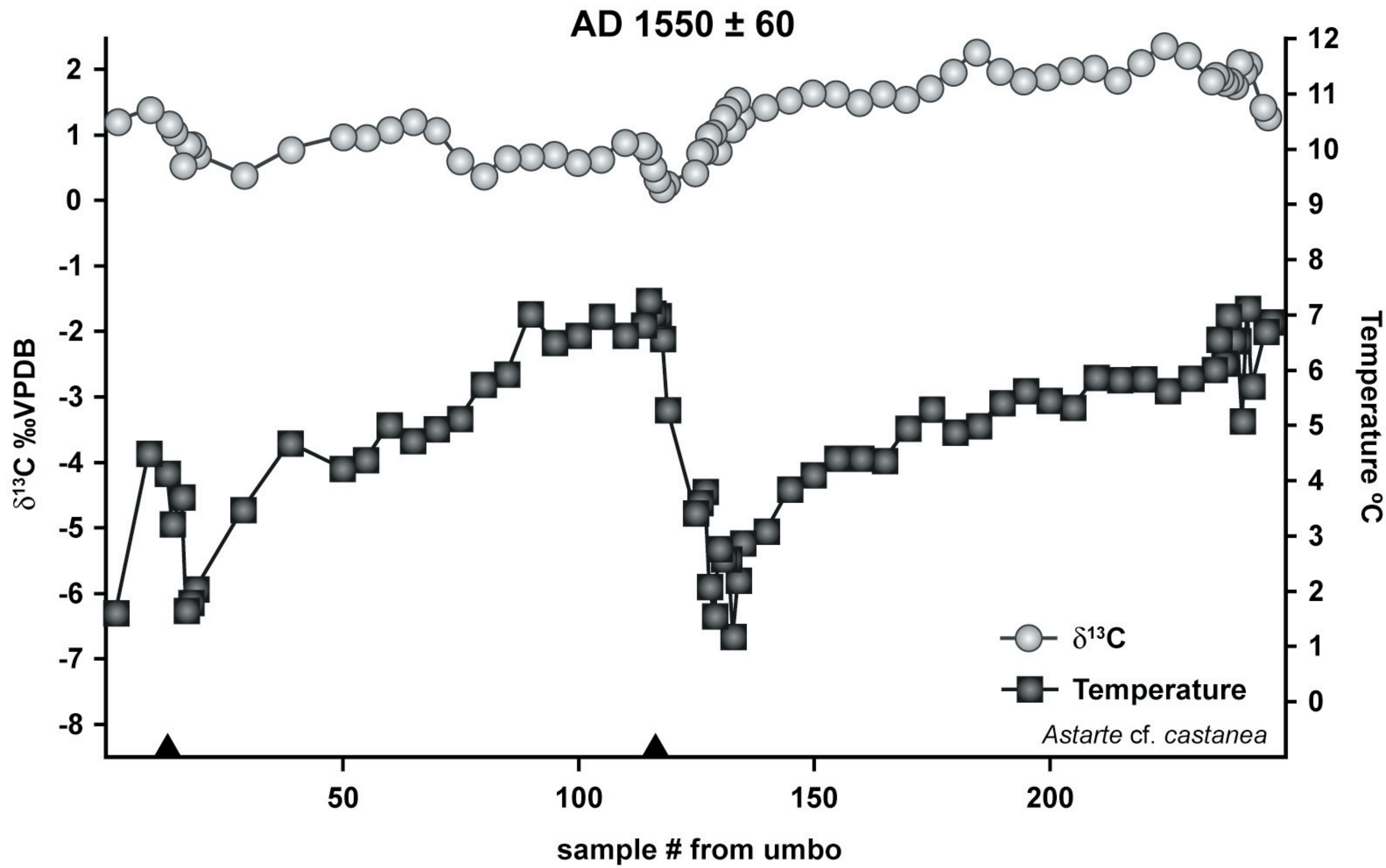


Fig. 2.31. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/26-26.5 cm, c. AD 1550. Arrows along the horizontal axis indicate the position of annual external growth lines.

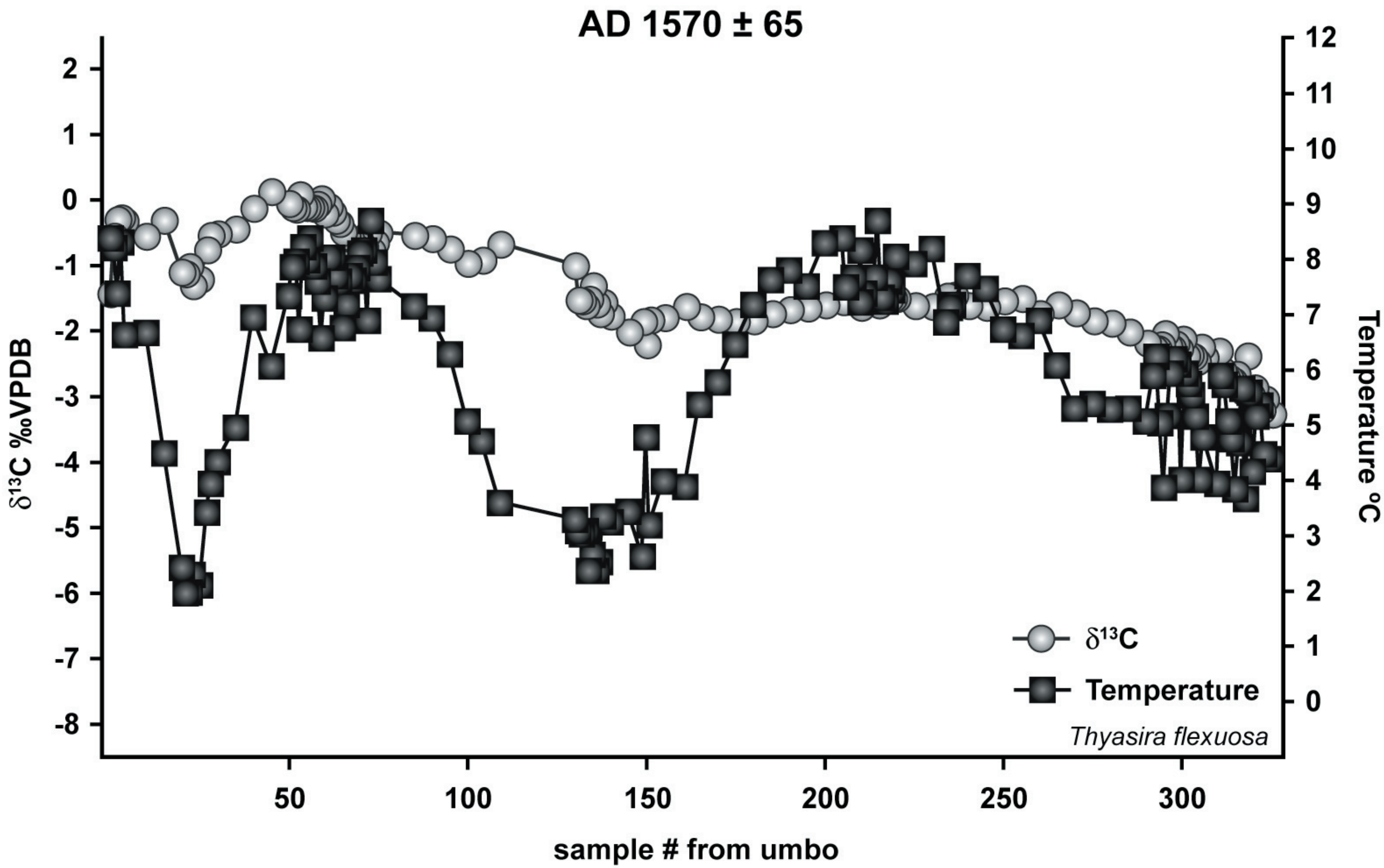


Fig. 2.32. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/24-25 cm, c. AD 1570.

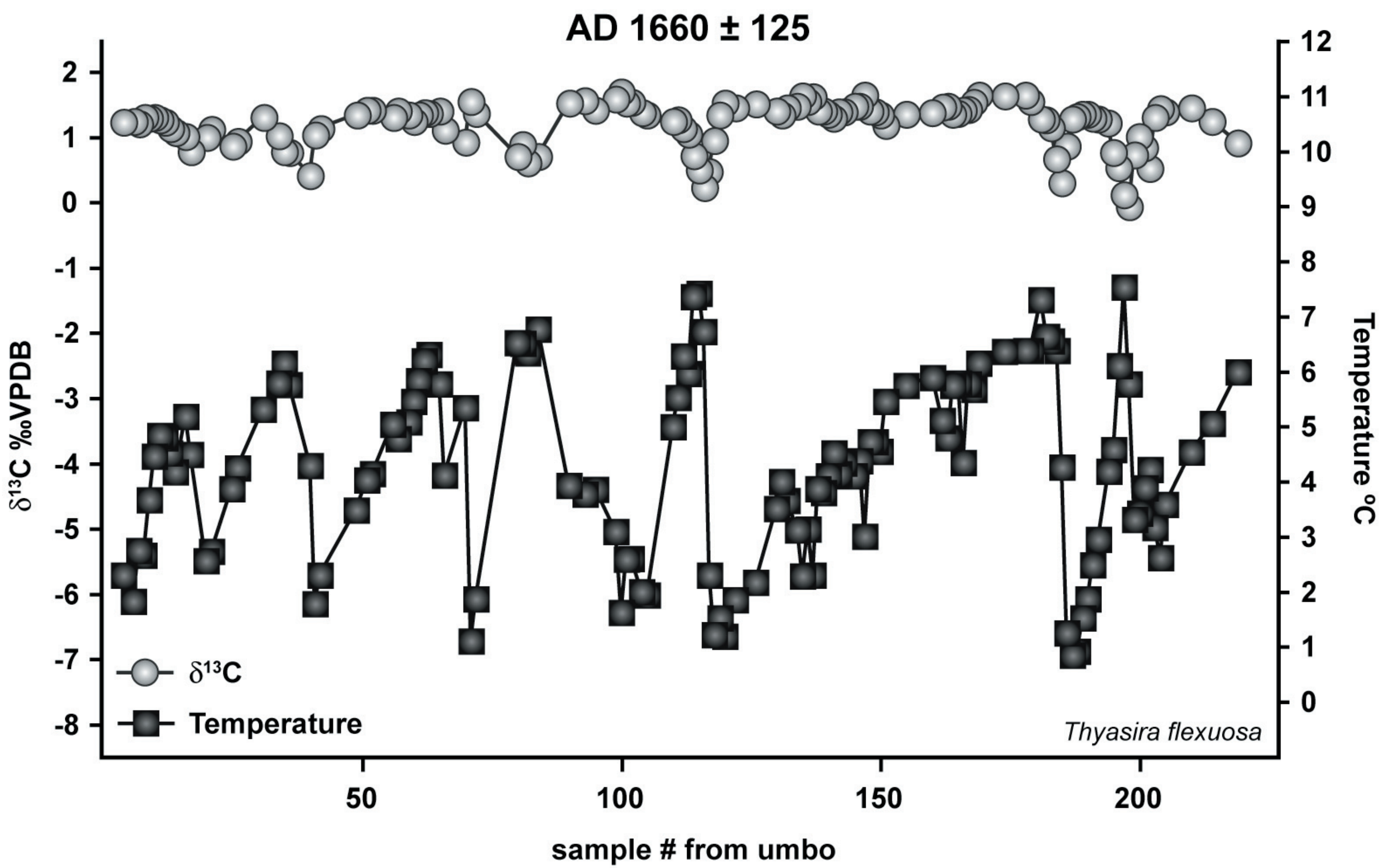


Fig. 2.33. $\delta^{13}C$ values and reconstructed temperatures of shell MD99-2266/9.5-10.5 cm, c. AD 1660.

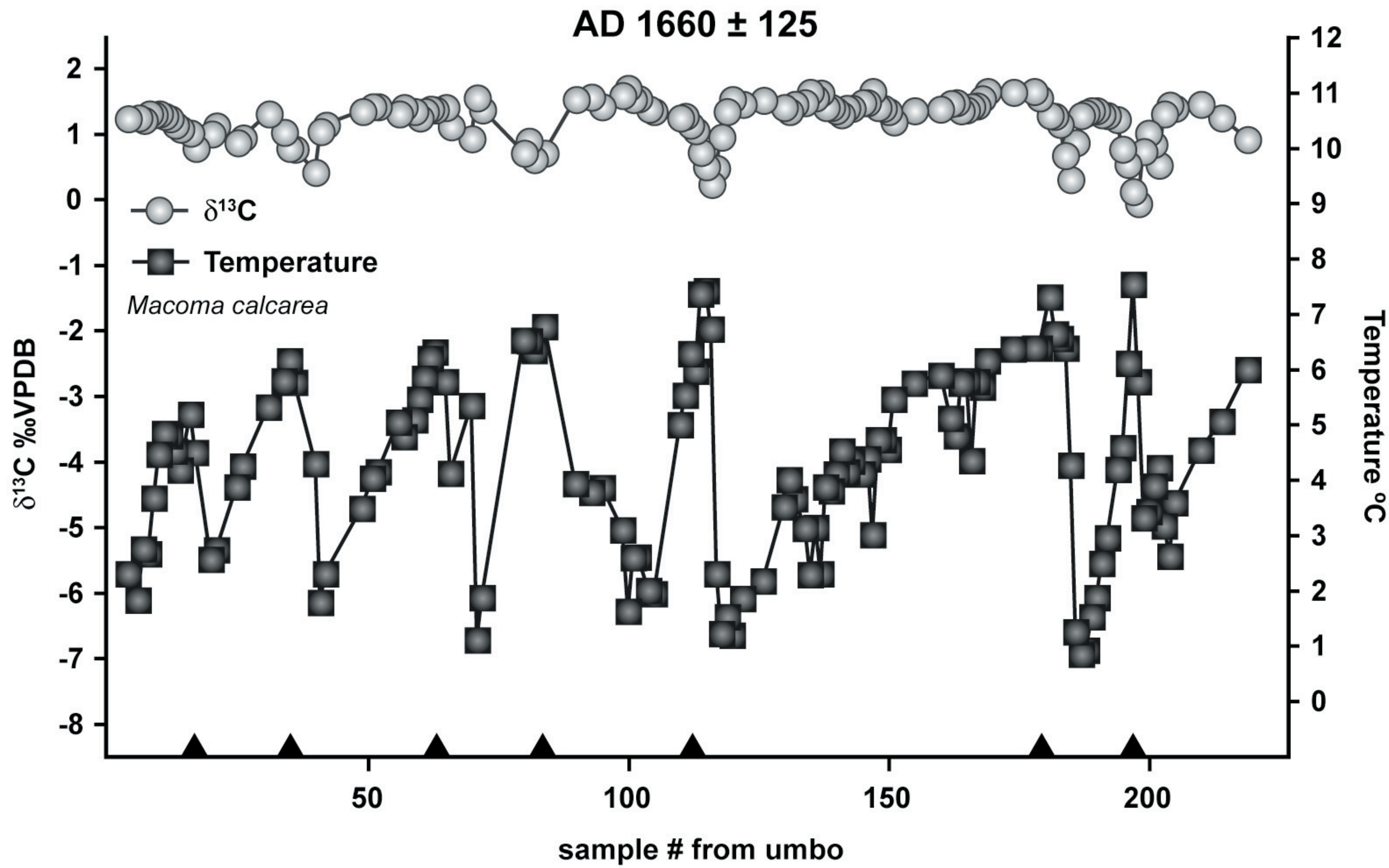


Fig. 2.34. $\delta^{13}C$ values and reconstructed temperatures of shell B997-341/9.5cm, c. AD 1660. Arrows along the horizontal axis indicate the position of annual external growth lines.

### 2.7.7 Comparisons to modern climate

In comparison to modern hydrographic measurements, our results indicate that water temperatures have been as high, and even slightly higher, than the temperatures reached in the present century. Temperatures have been as low several times in the past 2,400 years as they were during the Great Salinity Anomaly of 1968-1971, possibly caused by similar processes. The reconstructed temperatures of our record also indicate greater variability in winter temperatures than summer, in accord with air temperatures for Iceland, with variability in winter twice that of the summer months (Hanna et al., 2004).

## 2.8 Conclusion

Iceland is particularly sensitive to changes in the climate regimes of the north Atlantic region due to its position close to the margins of water masses of Atlantic and Arctic origin. Twenty-six bivalve specimens were recovered from marine sediment cores collected off the northern and northwestern coasts of Iceland, and the shells were microsampled and analyzed for stable oxygen and carbon isotope values, providing the first record of seasonal temperatures and the first qualitative high-resolution record of temperature variability in this important climate region over the last ~2,400 years.

The entire time-series of climate snapshots is shown in Fig. 2.35. The series of discrete intervals from 360 BC to AD 1660 shows variation in both summer and winter temperatures, with coldest temperatures (0-1ºC) reached at AD 470, 1120, 1380, 1420, and 1660; and warmest temperatures (above 9ºC) recorded from 220 BC to AD 140, and at AD 640, 960, 1250, and 1570. Previously identified warm and cold intervals have been characterized in terms of maximum and minimum seasonal temperatures. The Roman Warm Period in Iceland is characterized by remarkably high summer (13ºC, the highest temperature for the entire record) and winter temperatures, while warm but not exceptional summer temperatures and cool winter temperatures characterize the Medieval Warm Period. Written documents indicate that sea exploration in the North Atlantic and the subsequent settlement of Iceland and Greenland occurred during a period of sustained and consistent warmth. High winter temperatures at this time indicate that passages from Norway to Iceland and Greenland would have remained ice-free year-round. Following the first hundred years of settlement in Iceland, decreases in summer and winter temperatures resulted in more frequent crop failures and winters that were harder to survive. Greater variation in winter temperatures could have made subsistence strategies more difficult to implement. Lower winter temperatures could also result in greater frequency and duration of sea-ice, making sea travel more difficult and perhaps contributing to the abandonment of Greenland settlements. The onset of the Little Ice Age is characterized by consistently low minimum winter temperatures.

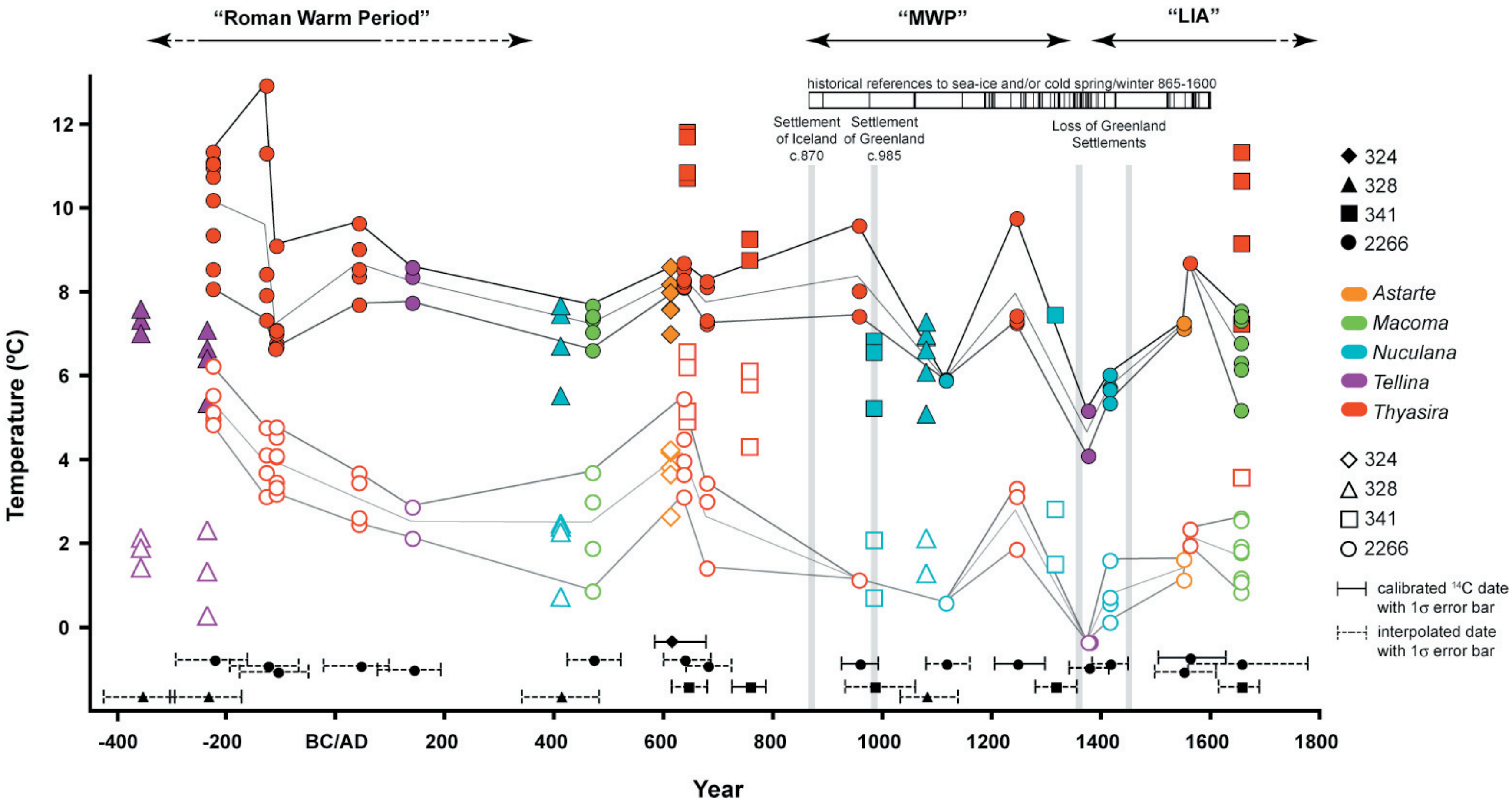


Fig. 2.35. Temperatures derived from the $\delta^{18}O_{aragonite}$ values of marine bivalves. Minimum $\delta^{18}O_{aragonite}$ values are interpreted as peak summer temperatures (solid symbols) and maximum $\delta^{18}O_{aragonite}$ values as minimum winter temperatures (open symbols). Thin lines within the shaded areas connect the average peak summer temperatures and average minimum winter temperature for each shell record.

This is the first quantitative subseasonal to subweekly climate record for the northern and northwest Iceland shelf, providing evidence of rapid climate change and variability in seasonal temperatures.

## 2.9 Acknowledgements

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**APPENDIX:**
**OXYGEN AND CARBON STABLE ISOTOPE VALUES OF MARINE BIVALVES**

| Core | Depth (cm) | Species | Sample # | Lab # | $\delta^{18}O$ ‰VPDB | $\delta^{13}C$ ‰VPDB |
|---|---|---|---|---|---|---|
| B997-324PC1 | 30-32 | *Astarte borealis* | 0 | 5785 | 2.42 | -0.02 |
| | | | 1 | 5786 | 2.43 | 0.08 |
| | | | 5 | 5787 | 2.49 | 0.18 |
| | | | 6 | 6621 | 2.55 | 0.43 |
| | | | 9 | 6623 | 2.38 | 0.20 |
| | | | 10 | 5788 | 2.16 | -0.13 |
| | | | 11 | 6624 | 2.27 | -0.29 |
| | | | 19 | 6811 | 2.52 | 0.71 |
| | | | 20 | 5789 | 2.80 | 0.63 |
| | | | 21 | 6814 | 2.44 | 0.20 |
| | | | 22 | 6625 | 2.32 | -0.08 |
| | | | 23 | 6812 | 2.42 | -0.05 |
| | | | 25 | 6825 | 2.51 | -0.39 |
| | | | 36 | 6827 | 2.17 | -0.49 |
| | | | 37 | 6826 | 2.06 | -0.55 |
| | | | 38 | 6813 | 2.20 | -0.67 |
| | | | 39 | 6627 | 2.24 | -0.48 |
| | | | 40 | 5790 | 2.34 | -0.13 |
| | | | 42 | 6815 | 2.52 | 0.49 |
| | | | 45 | 6816 | 2.76 | 0.64 |
| | | | 46 | 392 | 3.20 | 0.92 |
| | | | 47 | 393 | 2.83 | 0.45 |
| | | | 48 | 394 | 2.76 | 0.32 |
| | | | 52 | 395 | 2.43 | -0.31 |
| | | | 53 | 3383 | 2.29 | -0.27 |
| | | | 54 | 396 | 2.53 | -0.37 |
| | | | 60 | 5791 | 2.75 | -0.25 |
| | | | 71 | 397 | 3.03 | 0.63 |
| | | | 73 | 398 | 3.16 | 0.52 |
| | | | 75 | 3384 | 3.24 | 0.49 |
| | | | 76 | 691 | 3.08 | -0.27 |
| | | | 78 | 6828 | 2.91 | 0.43 |
| | | | 80 | 5792 | 3.01 | 0.66 |
| | | | 82 | 6629 | 2.96 | 0.24 |
| | | | 84 | 6630 | 2.49 | -0.04 |

| | | | |
|---|---|---|---|
| 85 | 6818 | 2.20 | -0.25 |
| 87 | 6819 | 2.33 | -0.06 |
| 100 | 5793 | 2.92 | 0.58 |
| 102 | 6829 | 3.11 | 1.18 |
| 103 | 399 | 2.93 | 0.98 |
| 119 | 6632 | 2.53 | -0.07 |
| 120 | 5794 | 2.30 | -0.15 |
| 121 | 6633 | 2.52 | 0.14 |
| 121 | 3422 | 2.36 | 0.00 |
| 135 | 402 | 3.44 | 1.50 |
| 136 | 3382 | 3.48 | 1.61 |
| 138 | 3381 | 3.12 | 1.06 |
| 140 | 5795 | 3.09 | 1.05 |
| 142 | 3423 | 2.93 | 0.83 |
| 148 | 403 | 2.67 | 0.35 |
| 149 | 3424 | 2.44 | 0.28 |
| 150 | 6634 | 2.51 | -0.05 |
| 151 | 3425 | 2.58 | 0.26 |
| 160 | 5796 | 3.04 | 0.75 |
| 162 | 1057 | 2.95 | 0.64 |
| 163 | 1058 | 3.10 | 0.97 |
| 165 | 404 | 3.02 | 0.46 |
| 170 | 6635 | 2.90 | 0.50 |
| 180 | 5797 | 3.08 | 1.43 |
| 182 | 405 | 2.87 | 0.92 |
| 199 | 6636 | 2.87 | 0.48 |
| 200 | 5798 | 2.71 | 0.32 |
| 201 | 6637 | 2.89 | 0.71 |
| 219 | 5799 | 3.15 | 1.13 |
| 240 | 5800 | 3.32 | 1.68 |
| 258 | 6638 | 3.36 | 0.93 |
| 260 | 5801 | 3.44 | 1.00 |
| 261 | 406 | 3.34 | 1.13 |
| 262 | 3427 | 3.23 | 0.79 |
| 280 | 5802 | 3.34 | 1.43 |
| 298 | 3428 | 3.13 | 1.32 |
| 300 | 5803 | 2.90 | 0.92 |
| 302 | 3429 | 3.14 | 1.06 |
| 303 | 408 | 3.05 | 1.08 |
| 319 | 414 | 2.89 | 1.16 |
| 320 | 5804 | 3.38 | 1.97 |
| 321 | 409 | 3.24 | 1.10 |
| 323 | 410 | 3.09 | 1.10 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 324 | 3431 | 2.99 | 1.00 |
| | | | 340 | 5808 | 3.36 | 0.76 |
| | | | 342 | 1054 | 3.29 | 1.28 |
| | | | 344 | 1055 | 2.98 | 1.26 |
| | | | 350 | 5809 | 3.37 | 1.47 |
| | | | 358 | 5810 | 3.30 | 0.58 |
| B997-328PC | 100-101.25 | *Nuculana tenuisulacata* | 0 | 5063 | 3.33 | -1.38 |
| | | | 1 | 5064 | 3.30 | -1.43 |
| | | | 7 | 699 | 2.75 | -1.41 |
| | | | 8 | 700 | 2.80 | -1.45 |
| | | | 9 | 417 | 3.03 | -1.23 |
| | | | 10 | 5066 | 3.43 | -1.00 |
| | | | 12 | 3385 | 3.27 | -0.67 |
| | | | 16 | 701 | 2.96 | -0.68 |
| | | | 19 | 6801 | 3.40 | -0.29 |
| | | | 22 | 6802 | 3.13 | 0.32 |
| | | | 24 | 3387 | 3.28 | 0.44 |
| | | | 29 | 419 | 2.75 | 0.34 |
| | | | 30 | 5068 | 3.48 | 0.46 |
| | | | 31 | 704 | 3.04 | 0.35 |
| | | | 32 | 3388 | 3.36 | 0.52 |
| | | | 34 | 3389 | 3.40 | 0.59 |
| | | | 40 | 5069 | 3.19 | 0.35 |
| | | | 41 | 6803 | 2.98 | 0.26 |
| | | | 46 | 6804 | 2.67 | -0.16 |
| | | | 48 | 3390 | 2.86 | -0.04 |
| | | | 52 | 3391 | 2.75 | -0.30 |
| | | | 60 | 5071 | 3.28 | -0.70 |
| | | | 68 | 5506 | 3.32 | -0.72 |
| | | | 70 | 5072 | 3.56 | -0.54 |
| | | | 76 | 3393 | 3.49 | -0.74 |
| | | | 80 | 5073 | 3.44 | -1.09 |
| | | | 84 | 3394 | 3.45 | -1.29 |
| | | | 87 | 6806 | 3.46 | -1.43 |
| | | | 92 | 6807 | 3.42 | -1.13 |
| | | | 100 | 5075 | 3.69 | -0.43 |
| | | | 105 | 5508 | 3.86 | 0.27 |
| | | | 108 | 6808 | 3.79 | 0.48 |
| | | | 110 | 5076 | 3.93 | 0.47 |
| | | | 111 | 421 | 3.69 | 0.63 |
| | | | 119 | 5509 | 3.17 | 0.26 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 120 | 5077 | 3.27 | 0.31 |
| | | | 121 | 5510 | 3.12 | 0.18 |
| | | | 122 | 6809 | 2.83 | 0.16 |
| | | | 123 | 422 | 2.94 | -0.02 |
| | | | 130 | 5078 | 3.89 | -0.11 |
| | | | 138 | 6810 | 3.94 | 0.21 |
| | | | 139 | 705 | 3.97 | 0.17 |
| | | | 140 | 5079 | 4.14 | 0.85 |
| | | | 141 | 706 | 3.20 | 1.19 |
| | | | 143 | 1063 | 3.57 | 1.00 |
| | | | 146 | 5080 | 3.52 | 1.52 |
| B997-328PC | 168.75-171.25 | *Nuculana tenuisulacata* | 1 | 5176 | 1.83 | 3.17 |
| | | | 8 | 6723 | 2.24 | 3.09 |
| | | | 9 | 5726 | 1.59 | 2.92 |
| | | | 14 | 707 | 1.20 | 3.43 |
| | | | 20 | 5179 | 0.84 | 3.30 |
| | | | 22 | 5728 | 0.24 | 3.48 |
| | | | 23 | 708 | 0.10 | 3.11 |
| | | | 24 | 6725 | 0.54 | 3.71 |
| | | | 26 | 423 | 0.69 | 3.67 |
| | | | 30 | 5180 | 1.33 | 3.25 |
| | | | 38 | 6727 | 1.51 | 3.37 |
| | | | 40 | 5181 | 1.27 | 3.23 |
| | | | 50 | 5182 | 1.40 | 3.49 |
| | | | 54 | 6729 | 1.31 | 3.31 |
| | | | 60 | 5183 | 1.12 | 3.39 |
| | | | 68 | 709 | -0.50 | 2.94 |
| | | | 70 | 5184 | -0.48 | 3.08 |
| | | | 71 | 6731 | -0.58 | 3.09 |
| | | | 80 | 5185 | 0.39 | 3.41 |
| | | | 90 | 5186 | 0.42 | 3.50 |
| | | | 100 | 5187 | -0.18 | 3.65 |
| | | | 110 | 5188 | 1.10 | 3.45 |
| | | | 119 | 6733 | 0.70 | 3.80 |
| | | | 120 | 5189 | 0.71 | 3.84 |
| | | | 123 | 710 | 0.82 | 3.30 |
| | | | 127 | 714 | 0.67 | 2.80 |
| | | | 128 | 425 | 0.47 | 2.63 |
| | | | 129 | 6735 | 0.40 | 2.78 |
| | | | 130 | 5190 | 0.28 | 2.87 |
| | | | 140 | 5191 | -0.79 | 3.34 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 150 | 5192 | -0.46 | 3.57 |
| | | | 159 | 6737 | -0.44 | 3.75 |
| | | | 160 | 5193 | -0.44 | 3.86 |
| | | | 162 | 426 | -0.24 | 3.78 |
| | | | 170 | 5194 | 0.18 | 3.48 |
| | | | 179 | 715 | 0.21 | 2.68 |
| | | | 180 | 5198 | 0.07 | 2.63 |
| | | | 181 | 716 | 0.08 | 2.58 |
| | | | 182 | 1067 | -0.23 | 2.77 |
| | | | 183 | 1068 | -0.18 | 2.67 |
| | | | 190 | 5199 | -0.20 | 3.24 |
| | | | 200 | 5200 | -0.34 | 3.68 |
| | | | 208 | 428 | 0.07 | 3.80 |
| | | | 210 | 5201 | 0.46 | 4.27 |
| | | | 211 | 718 | 0.52 | 3.90 |
| | | | 212 | 429 | 0.22 | 3.74 |
| | | | 220 | 5202 | 0.06 | 3.18 |
| | | | 221 | 431 | 0.34 | 2.81 |
| | | | 223 | 720 | -0.01 | 3.19 |
| | | | 230 | 5203 | -0.06 | 3.73 |
| | | | 238 | 432 | 0.09 | 3.86 |
| | | | 240 | 5204 | 0.37 | 3.89 |
| | | | 242 | 721 | 0.13 | 3.55 |
| | | | 248 | 722 | 0.26 | 3.25 |
| | | | 250 | 5205 | -0.09 | 3.31 |
| | | | 251 | 723 | -0.02 | 3.09 |
| | | | 255 | 5206 | 0.39 | 3.63 |
| | | | 256 | 5207 | 0.18 | 3.63 |
| B997-328PC | 238.5-241.25 | *Tellina tenuis* | 0 | 558 | 3.45 | 1.05 |
| | | | 1 | 872 | 3.41 | 0.87 |
| | | | 2 | 964 | 3.23 | 0.69 |
| | | | 6 | 2767 | 3.14 | -0.27 |
| | | | 7 | 2768 | 3.28 | 0.04 |
| | | | 8 | 2769 | 3.61 | 0.65 |
| | | | 9 | 567 | 3.79 | 1.09 |
| | | | 14 | 568 | 3.90 | 1.28 |
| | | | 19 | 569 | 3.88 | 1.68 |
| | | | 21 | 966 | 3.93 | 1.70 |
| | | | 22 | 967 | 4.05 | 1.83 |
| | | | 23 | 874 | 4.39 | 1.25 |
| | | | 24 | 570 | 3.97 | 2.04 |
| | | | 25 | 875 | 3.53 | 0.54 |

| | | | |
|---|---|---|---|
| 27 | 881 | 2.72 | -0.64 |
| 28 | 882 | 2.77 | -0.29 |
| 29 | 571 | 3.11 | -0.07 |
| 30 | 883 | 2.98 | -0.02 |
| 31 | 884 | 2.90 | 0.05 |
| 32 | 968 | 3.13 | -0.04 |
| 34 | 572 | 3.33 | 0.46 |
| 39 | 573 | 3.53 | 0.82 |
| 41 | 974 | 3.57 | 1.04 |
| 42 | 885 | 3.31 | 0.99 |
| 43 | 886 | 3.49 | 0.91 |
| 44 | 574 | 3.88 | 1.15 |
| 45 | 887 | 3.45 | 0.94 |
| 46 | 888 | 3.46 | 0.98 |
| 47 | 975 | 3.69 | 0.90 |
| 48 | 976 | 3.70 | 0.81 |
| 49 | 575 | 3.69 | 0.97 |
| 50 | 977 | 3.73 | 1.00 |
| 53 | 2770 | 4.12 | 1.29 |
| 54 | 576 | 3.04 | 0.44 |
| 57 | 980 | 3.15 | -0.49 |
| 58 | 889 | 2.82 | 0.08 |
| 59 | 577 | 2.99 | 0.18 |
| 60 | 890 | 2.87 | 0.36 |
| 61 | 981 | 3.10 | 0.25 |
| 64 | 578 | 3.14 | -0.38 |
| 69 | 579 | 3.06 | 0.63 |
| 74 | 580 | 3.14 | -0.23 |
| 79 | 581 | 3.41 | 0.86 |
| 84 | 582 | 3.40 | 1.13 |
| 89 | 583 | 3.46 | 1.28 |
| 94 | 588 | 3.40 | 0.92 |
| 98 | 891 | 3.40 | 1.16 |
| 99 | 589 | 3.60 | 1.37 |
| 100 | 892 | 3.15 | 1.22 |
| 101 | 982 | 3.39 | 1.27 |
| 103 | 893 | 3.28 | 0.79 |
| 104 | 590 | 3.24 | 1.19 |
| 105 | 894 | 3.40 | 0.20 |
| 109 | 591 | 3.29 | 1.04 |
| 114 | 592 | 3.51 | 1.02 |
| 117 | 983 | 3.47 | 0.53 |
| 118 | 895 | 3.29 | 0.58 |

| | | | |
|---|---|---|---|
| 119 | 593 | 3.74 | 0.94 |
| 120 | 896 | 3.45 | 0.27 |
| 121 | 984 | 3.69 | 0.28 |
| 123 | 985 | 3.63 | -0.08 |
| 124 | 594 | 3.64 | -0.29 |
| 125 | 986 | 3.72 | -0.44 |
| 126 | 2772 | 3.88 | -0.71 |
| 127 | 2773 | 3.57 | -2.46 |
| 128 | 2774 | 3.34 | -2.60 |
| 129 | 595 | 3.33 | -1.54 |
| 130 | 2775 | 2.88 | -1.78 |
| 131 | 987 | 2.96 | -1.09 |
| 132 | 988 | 2.99 | -0.70 |
| 133 | 897 | 3.02 | -1.00 |
| 134 | 596 | 3.17 | -0.26 |
| 135 | 898 | 3.18 | -0.43 |
| 139 | 597 | 3.49 | 0.64 |
| 144 | 598 | 3.58 | 0.72 |
| 149 | 599 | 3.71 | 0.72 |
| 150 | 2776 | 3.54 | 0.73 |
| 151 | 2766 | 3.50 | 0.86 |
| 152 | 2777 | 3.58 | 1.02 |
| 154 | 600 | 3.72 | 1.07 |
| 155 | 2778 | 3.48 | 1.09 |
| 157 | 2779 | 3.67 | 1.12 |
| 158 | 989 | 3.39 | 1.02 |
| 159 | 601 | 3.74 | 1.09 |
| 160 | 990 | 3.50 | 0.86 |
| 164 | 602 | 3.63 | 0.92 |
| 169 | 603 | 3.55 | 0.75 |
| 174 | 604 | 3.72 | 1.17 |
| 179 | 605 | 3.57 | 0.80 |
| 184 | 606 | 3.61 | 0.71 |
| 189 | 648 | 3.48 | 0.55 |
| 194 | 649 | 3.53 | 0.82 |
| 196 | 2780 | 3.48 | -0.05 |
| 197 | 2781 | 3.60 | -0.41 |
| 198 | 2782 | 3.41 | -0.49 |
| 199 | 650 | 3.41 | -0.13 |
| 200 | 2783 | 3.51 | 0.01 |
| 201 | 2784 | 3.54 | 0.16 |
| 202 | 2785 | 3.60 | 0.29 |
| 204 | 651 | 3.59 | 0.61 |

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|---|---|---|---|---|---|---|
| | | | 209 | 652 | 3.71 | 0.85 |
| | | | 219 | 797 | 3.82 | 0.49 |
| | | | 224 | 798 | 3.77 | 0.68 |
| | | | 229 | 799 | 3.84 | 0.55 |
| | | | 233 | 2789 | 3.75 | 0.32 |
| | | | 234 | 800 | 3.89 | 0.39 |
| | | | 235 | 2790 | 3.85 | 0.27 |
| | | | 239 | 801 | 3.69 | -0.42 |
| | | | 244 | 802 | 3.82 | -0.22 |
| | | | 249 | 803 | 3.81 | 0.36 |
| | | | 254 | 804 | 3.73 | 0.23 |
| | | | 259 | 805 | 3.83 | 0.46 |
| | | | 264 | 806 | 3.94 | 0.75 |
| | | | 268 | 1014 | 3.95 | 0.60 |
| | | | 269 | 807 | 3.96 | 0.49 |
| | | | 271 | 1177 | 3.81 | 0.40 |
| | | | 274 | 951 | 3.84 | 0.48 |
| | | | 279 | 952 | 4.00 | 0.63 |
| | | | 284 | 953 | 3.98 | 0.77 |
| | | | 289 | 954 | 4.04 | 0.15 |
| | | | 294 | 955 | 4.01 | 0.10 |
| | | | 299 | 956 | 3.93 | -0.20 |
| | | | 304 | 957 | 3.89 | -0.98 |
| | | | 309 | 958 | 3.87 | -0.74 |
| | | | 310 | 959 | 3.92 | -0.47 |
| | | | 311 | 960 | 3.94 | -0.65 |
| | | | 312 | 961 | 3.96 | -0.39 |
| | | | 313 | 962 | 4.02 | -0.43 |
| B997-328PC | 248.75-257.25 | *Tellina tenuis* | 0 | 13682 | 3.48 | -0.23 |
| | | | 2 | 865 | 2.89 | -0.50 |
| | | | 3 | 14719 | 3.10 | -0.20 |
| | | | 4 | 13683 | 2.96 | -0.15 |
| | | | 8 | 13684 | 3.35 | 0.79 |
| | | | 9 | 14722 | 3.34 | 0.78 |
| | | | 10 | 2719 | 3.29 | 0.95 |
| | | | 11 | 2720 | 3.29 | 0.95 |
| | | | 12 | 14723 | 3.11 | 0.86 |
| | | | 13 | 14724 | 3.25 | 1.00 |
| | | | 14 | 13685 | 3.10 | 1.00 |
| | | | 19 | 13686 | 3.25 | 0.32 |
| | | | 24 | 13687 | 3.52 | 0.76 |

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|---|---|---|---|
| 27 | 14725 | 3.67 | 1.14 |
| 28 | 14726 | 3.76 | 1.23 |
| 29 | 13688 | 3.92 | 1.44 |
| 30 | 14727 | 3.75 | 1.38 |
| 32 | 866 | 3.66 | 1.25 |
| 33 | 867 | 3.56 | 1.30 |
| 34 | 13689 | 3.81 | 1.53 |
| 35 | 2722 | 3.72 | 1.51 |
| 39 | 13690 | 3.60 | 1.14 |
| 44 | 13691 | 3.14 | 0.78 |
| 45 | 2723 | 3.11 | 0.84 |
| 46 | 868 | 2.66 | 0.98 |
| 47 | 869 | 2.72 | 1.07 |
| 48 | 14729 | 2.70 | 1.32 |
| 49 | 13692 | 2.86 | 1.46 |
| 50 | 14730 | 2.70 | 1.47 |
| 51 | 14731 | 2.77 | 1.47 |
| 52 | 14732 | 2.77 | 1.45 |
| 53 | 14733 | 2.81 | 1.38 |
| 54 | 13693 | 2.83 | 1.37 |
| 55 | 14734 | 2.79 | 1.34 |
| 59 | 13694 | 2.96 | 1.30 |
| 64 | 13695 | 3.19 | 1.18 |
| 68 | 14735 | 3.14 | 1.16 |
| 69 | 13696 | 3.28 | 1.27 |
| 70 | 14736 | 3.17 | 1.16 |
| 74 | 13697 | 3.22 | 1.29 |
| 79 | 13698 | 3.23 | 1.21 |
| 85 | 14503 | 3.22 | 0.95 |
| 89 | 14737 | 3.28 | 0.86 |
| 90 | 14504 | 3.07 | 0.79 |
| 91 | 14742 | 3.22 | 0.86 |
| 95 | 14505 | 3.14 | 0.75 |
| 100 | 14506 | 3.14 | 0.75 |
| 103 | 14745 | 3.29 | 0.77 |
| 104 | 14746 | 3.26 | 0.73 |
| 105 | 14507 | 3.14 | 0.71 |
| 110 | 14508 | 3.32 | 0.68 |
| 111 | 14743 | 3.42 | 0.70 |
| 112 | 14744 | 3.60 | 0.78 |
| 113 | 14747 | 3.63 | 0.82 |
| 114 | 14748 | 3.65 | 0.83 |
| 115 | 14509 | 3.75 | 0.94 |

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|---|---|---|---|
| 116 | 14749 | 3.84 | 0.91 |
| 120 | 14510 | 3.55 | 0.86 |
| 124 | 2726 | 3.51 | 0.43 |
| 125 | 14511 | 3.47 | 0.41 |
| 126 | 2727 | 3.53 | 0.42 |
| 128 | 2729 | 3.68 | 0.48 |
| 129 | 2730 | 3.73 | 0.48 |
| 130 | 14512 | 3.53 | 0.48 |
| 135 | 14513 | 3.61 | 0.90 |
| 140 | 14514 | 3.73 | 1.17 |
| 144 | 14753 | 3.72 | 1.32 |
| 145 | 14515 | 3.63 | 1.35 |
| 146 | 14754 | 3.75 | 1.44 |
| 147 | 14755 | 3.73 | 1.48 |
| 150 | 14516 | 3.70 | 1.60 |
| 153 | 14756 | 3.74 | 1.58 |
| 154 | 14757 | 3.76 | 1.57 |
| 156 | 870 | 3.52 | 1.34 |
| 157 | 871 | 3.71 | 1.20 |
| 158 | 14758 | 3.98 | 1.47 |
| 160 | 14518 | 3.51 | 1.07 |
| 161 | 14760 | 3.56 | 0.98 |
| 164 | 920 | 3.56 | 0.93 |
| 165 | 921 | 3.81 | 0.91 |
| 166 | 812 | 2.71 | 0.60 |
| 167 | 1006 | 2.70 | 0.49 |
| 168 | 1007 | 2.95 | 0.65 |
| 170 | 1008 | 2.87 | 0.59 |
| 171 | 813 | 3.33 | 0.67 |
| 172 | 1009 | 3.42 | 0.94 |
| 173 | 2731 | 3.31 | 0.81 |
| 176 | 814 | 3.35 | 0.25 |
| 177 | 933 | 2.67 | 0.74 |
| 179 | 934 | 2.64 | 0.90 |
| 180 | 935 | 2.60 | 1.04 |
| 181 | 815 | 2.87 | 0.90 |
| 182 | 936 | 2.64 | 1.28 |
| 183 | 937 | 2.78 | 1.16 |
| 189 | 2305 | 3.18 | 1.14 |
| 190 | 2306 | 3.28 | 1.19 |
| 191 | 817 | 3.24 | 1.02 |
| 192 | 2307 | 3.28 | 1.10 |
| 193 | 2308 | 3.22 | 1.07 |

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|---|---|---|---|
| 194 | 2309 | 3.26 | 1.05 |
| 195 | 938 | 3.01 | 1.13 |
| 196 | 818 | 3.35 | 0.95 |
| 197 | 939 | 3.33 | 1.04 |
| 198 | 2310 | 3.51 | 1.12 |
| 199 | 940 | 3.18 | 0.94 |
| 202 | 942 | 3.02 | 1.15 |
| 203 | 943 | 3.19 | 1.02 |
| 206 | 820 | 3.32 | 0.72 |
| 211 | 821 | 3.43 | 0.73 |
| 216 | 822 | 3.43 | 0.54 |
| 221 | 823 | 3.45 | 0.63 |
| 226 | 824 | 3.51 | 0.53 |
| 231 | 825 | 3.65 | 0.46 |
| 236 | 826 | 3.65 | 0.45 |
| 241 | 827 | 3.74 | 0.34 |
| 246 | 828 | 3.80 | 0.02 |
| 251 | 829 | 3.68 | 0.42 |
| 256 | 830 | 3.73 | 0.21 |
| 260 | 2733 | 3.97 | 0.43 |
| 261 | 835 | 3.72 | 0.13 |
| 262 | 2734 | 3.65 | 0.31 |
| 266 | 836 | 3.59 | 0.57 |
| 271 | 837 | 3.78 | 0.20 |
| 276 | 838 | 3.75 | 0.30 |
| 278 | 2312 | 3.69 | 0.31 |
| 279 | 2311 | 3.77 | 0.37 |
| 280 | 944 | 3.48 | 0.32 |
| 281 | 839 | 3.95 | 0.05 |
| 282 | 945 | 3.62 | 0.23 |
| 286 | 840 | 3.68 | 0.41 |
| 291 | 841 | 3.65 | 0.47 |
| 292 | 2313 | 3.64 | 0.53 |
| 293 | 2314 | 3.83 | 0.56 |
| 294 | 2315 | 3.90 | 0.64 |
| 295 | 1005 | 3.21 | 0.32 |
| 296 | 842 | 4.05 | 0.09 |
| 297 | 1010 | 3.62 | 0.60 |
| 298 | 2316 | 3.72 | 0.55 |
| 301 | 843 | 3.72 | 0.65 |
| 304 | 2317 | 3.88 | 0.79 |
| 305 | 2318 | 4.00 | 0.87 |
| 306 | 844 | 3.87 | 0.60 |

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|---|---|---|---|
| 307 | 2319 | 4.10 | 0.39 |
| 308 | 2320 | 3.98 | 0.35 |
| 311 | 845 | 3.46 | -0.08 |
| 313 | 2321 | 2.95 | 0.00 |
| 314 | 2322 | 2.81 | 0.31 |
| 315 | 1011 | 2.74 | 0.58 |
| 316 | 846 | 2.76 | 0.33 |
| 317 | 1012 | 2.80 | 0.62 |
| 318 | 1013 | 2.84 | 0.67 |
| 319 | 2369 | 2.93 | 0.53 |
| 320 | 2328 | 2.89 | 0.46 |
| 321 | 847 | 2.78 | 0.35 |
| 322 | 2329 | 3.00 | 0.54 |
| 323 | 2330 | 2.97 | 0.54 |
| 326 | 848 | 3.19 | 0.05 |
| 331 | 849 | 3.26 | 0.42 |
| 336 | 850 | 3.21 | 0.47 |
| 341 | 851 | 3.23 | 0.42 |
| 346 | 852 | 3.28 | -0.39 |
| 349 | 2331 | 3.59 | -0.18 |
| 350 | 2332 | 3.57 | -0.40 |
| 351 | 853 | 3.58 | -0.27 |
| 352 | 2333 | 3.43 | -0.31 |
| 353 | 2334 | 3.55 | -0.33 |
| 354 | 2335 | 3.33 | -0.98 |
| 355 | 2336 | 3.30 | -1.06 |
| 356 | 858 | 3.33 | -1.17 |
| 357 | 2383 | 3.34 | -0.70 |
| 358 | 2384 | 3.36 | -0.30 |
| 361 | 859 | 3.61 | -0.16 |
| 364 | 2385 | 3.40 | 0.08 |
| 365 | 2386 | 3.45 | 0.10 |
| 366 | 860 | 3.84 | -0.31 |
| 368 | 2388 | 2.98 | -0.14 |
| 369 | 2735 | 3.25 | 0.24 |
| 370 | 2389 | 3.26 | 0.29 |
| 371 | 861 | 3.45 | 0.16 |
| 372 | 2390 | 3.39 | 0.21 |
| 373 | 2391 | 3.39 | 0.02 |
| 376 | 862 | 3.71 | -0.15 |
| 380 | 2392 | 3.60 | -1.24 |
| 381 | 863 | 3.79 | -1.13 |

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|---|---|---|---|---|---|---|
| B997-341PC3 | 9.5 | *Thyasira flexuosa* | 0 | 11157 | 1.53 | -7.94 |
| | | | 1 | 14134 | 1.71 | -7.67 |
| | | | 3 | 14112 | 1.53 | -7.41 |
| | | | 5 | 11158 | 1.43 | -6.92 |
| | | | 6 | 14972 | 1.65 | -6.31 |
| | | | 7 | 14973 | 1.83 | -6.49 |
| | | | 8 | 14113 | 1.99 | -6.44 |
| | | | 9 | 14114 | 2.07 | -6.19 |
| | | | 10 | 11159 | 2.14 | -6.40 |
| | | | 11 | 14115 | 2.25 | -6.81 |
| | | | 13 | 14975 | 1.89 | -6.37 |
| | | | 14 | 14976 | 1.90 | -6.06 |
| | | | 15 | 11160 | 1.80 | -5.87 |
| | | | 19 | 14116 | 1.78 | -5.59 |
| | | | 20 | 11161 | 1.74 | -5.52 |
| | | | 22 | 2802 | 1.58 | -5.48 |
| | | | 23 | 2803 | 1.72 | -5.34 |
| | | | 24 | 14117 | 1.85 | -5.22 |
| | | | 25 | 11162 | 1.85 | -5.10 |
| | | | 26 | 14118 | 1.92 | -5.45 |
| | | | 27 | 2804 | 1.81 | -5.75 |
| | | | 28 | 2805 | 1.97 | -5.94 |
| | | | 29 | 2806 | 1.80 | -6.01 |
| | | | 30 | 11163 | 1.80 | -6.30 |
| | | | 34 | 14119 | 1.79 | -6.73 |
| | | | 35 | 11164 | 1.75 | -7.04 |
| | | | 36 | 2807 | 1.96 | -7.00 |
| | | | 37 | 11191 | 1.81 | -8.17 |
| | | | 40 | 11165 | 1.90 | -6.56 |
| | | | 41 | 14977 | 2.22 | -5.85 |
| | | | 42 | 14978 | 2.16 | -4.94 |
| | | | 45 | 11166 | 2.50 | -5.01 |
| | | | 47 | 14979 | 2.30 | -5.46 |
| | | | 50 | 11167 | 1.99 | -5.74 |
| | | | 52 | 14120 | 1.93 | -5.70 |
| | | | 55 | 11168 | 1.98 | -5.12 |
| | | | 59 | 14121 | 2.29 | -4.95 |
| | | | 60 | 11169 | 2.38 | -5.01 |
| | | | 65 | 11170 | 2.43 | -5.83 |
| | | | 67 | 14122 | 2.30 | -4.68 |
| | | | 70 | 11171 | 2.33 | -4.65 |
| | | | 75 | 11172 | 2.36 | -3.70 |

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|---|---|---|---|
| 80 | 11173 | 2.10 | -4.07 |
| 85 | 11174 | 2.29 | -4.18 |
| 90 | 11175 | 2.38 | -4.28 |
| 91 | 11185 | 2.95 | -3.48 |
| 92 | 11186 | 3.06 | -2.88 |
| 94 | 11188 | 3.16 | -3.44 |
| 95 | 11176 | 3.05 | -3.38 |
| 100 | 11180 | 3.15 | -2.37 |
| 103 | 14124 | 3.24 | -1.97 |
| 105 | 11181 | 3.08 | -1.28 |
| 108 | 14132 | 3.26 | -1.10 |
| 109 | 14133 | 3.13 | -1.16 |
| 110 | 11182 | 2.53 | -1.61 |
| 111 | 14138 | 2.93 | -1.42 |
| 112 | 14139 | 2.87 | -1.55 |
| 113 | 14140 | 2.80 | -1.73 |
| 114 | 14141 | 2.67 | -2.07 |
| 115 | 11183 | 2.51 | -2.17 |
| 116 | 11189 | 2.55 | -2.39 |
| 117 | 11190 | 2.41 | -2.48 |
| 119 | 11184 | 2.38 | -2.59 |
| 120 | 14142 | 2.49 | -2.46 |
| 125 | 14143 | 2.56 | -2.29 |
| 131 | 14985 | 2.83 | -1.58 |
| 132 | 14986 | 2.90 | -1.46 |
| 133 | 14987 | 3.04 | -1.44 |
| 135 | 14145 | 3.13 | -1.63 |
| 136 | 14991 | 2.91 | -1.87 |
| 138 | 15003 | 3.17 | -2.07 |
| 143 | 15060 | 3.10 | -3.08 |
| 144 | 13728 | 2.84 | -3.60 |
| 145 | 13729 | 2.91 | -2.96 |
| 146 | 13730 | 3.18 | -3.27 |
| 147 | 2808 | 3.15 | -3.43 |
| 156 | 13731 | 2.91 | -2.52 |
| 158 | 13733 | 2.69 | -3.23 |
| 159 | 13734 | 3.10 | -3.04 |
| 160 | 14135 | 2.84 | -3.98 |
| 167 | 14147 | 2.84 | -3.37 |
| 172 | 14148 | 2.82 | -4.25 |
| 180 | 14995 | 2.88 | -3.69 |
| 184 | 14150 | 2.56 | -2.03 |
| 189 | 15001 | 2.73 | -3.09 |

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|---|---|---|---|---|---|---|
| B997-341PC3 | 35.25 | *Nuculana tenuisulacata* | 0 | 5537 | 3.36 | -1.15 |
| | | | 1 | 5538 | 3.27 | -1.10 |
| | | | 4 | 5600 | 3.17 | -1.07 |
| | | | 5 | 5539 | 3.30 | -1.07 |
| | | | 5 | 5605 | 3.30 | -1.04 |
| | | | 10 | 5540 | 3.38 | -1.07 |
| | | | 11 | 6652 | 3.26 | -1.02 |
| | | | 18 | 5601 | 3.14 | -1.02 |
| | | | 20 | 5541 | 3.22 | -0.99 |
| | | | 23 | 592 | 3.08 | -0.96 |
| | | | 38 | 5603 | 3.55 | -0.11 |
| | | | 40 | 5542 | 3.67 | -0.07 |
| | | | 42 | 5604 | 3.70 | 0.04 |
| | | | 44 | 6654 | 3.76 | 0.11 |
| | | | 46 | 593 | 3.57 | 0.10 |
| | | | 60 | 5543 | 3.41 | 0.28 |
| | | | 81 | 5606 | 2.77 | 0.57 |
| | | | 96 | 724 | 2.62 | 0.48 |
| | | | 97 | 725 | 2.63 | 0.49 |
| | | | 101 | 5607 | 2.33 | 0.31 |
| | | | 103 | 6655 | 2.60 | 0.46 |
| | | | 104 | 6656 | 2.60 | 0.50 |
| | | | 105 | 595 | 2.46 | 0.37 |
| | | | 120 | 5546 | 2.39 | 0.11 |
| | | | 140 | 5547 | 2.48 | -0.25 |
| | | | 160 | 5548 | 2.76 | 0.20 |
| | | | 180 | 5549 | 2.71 | -0.74 |
| | | | 190 | 5550 | 2.99 | -0.11 |
| | | | 195 | 5551 | 3.44 | 0.70 |
| | | | 196 | 5608 | 3.44 | 0.87 |
| | | | 197 | 5609 | 3.35 | 0.94 |
| B997-341PC3 | 56 | *Nuculana tenuisulacata* | 0 | 5042 | 3.82 | 0.03 |
| | | | 10 | 5045 | 3.58 | 1.35 |
| | | | 14 | 596 | 2.47 | 0.96 |
| | | | 16 | 3432 | 2.63 | 0.70 |
| | | | 18 | 3433 | 2.75 | 0.49 |
| | | | 19 | 5485 | 2.77 | 0.43 |
| | | | 20 | 5046 | 3.14 | 0.41 |
| | | | 21 | 5486 | 3.14 | 0.46 |
| | | | 30 | 5047 | 3.54 | 0.44 |

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|---|---|---|---|---|---|---|
| | | | 39 | 5487 | 3.39 | 0.44 |
| | | | 41 | 5491 | 3.42 | 0.44 |
| | | | 49 | 5492 | 3.49 | -0.01 |
| | | | 50 | 5049 | 3.72 | 0.04 |
| | | | 51 | 5493 | 3.59 | -0.04 |
| | | | 57 | 597 | 3.90 | 0.59 |
| | | | 59 | 5494 | 3.78 | 0.54 |
| | | | 60 | 5050 | 3.96 | 0.76 |
| | | | 61 | 5495 | 3.70 | 0.78 |
| | | | 70 | 5051 | 3.09 | 0.98 |
| | | | 75 | 5496 | 2.54 | 0.45 |
| | | | 77 | 3434 | 2.68 | 0.51 |
| | | | 78 | 3435 | 2.59 | 0.44 |
| | | | 80 | 5052 | 2.54 | 0.44 |
| | | | 85 | 1071 | 2.54 | -0.07 |
| | | | 88 | 5497 | 2.79 | 0.07 |
| | | | 93 | 3437 | 2.88 | 0.32 |
| | | | 99 | 5499 | 3.16 | 0.21 |
| | | | 100 | 5054 | 3.25 | 0.38 |
| | | | 101 | 5500 | 3.62 | 0.49 |
| | | | 104 | 3438 | 3.12 | 0.36 |
| | | | 105 | 3439 | 3.36 | 0.44 |
| | | | 110 | 5055 | 3.60 | 0.21 |
| | | | 114 | 599 | 3.54 | 0.24 |
| | | | 120 | 5056 | 3.59 | 0.61 |
| | | | 124 | 3440 | 3.43 | 1.44 |
| | | | 125 | 5501 | 2.86 | 1.23 |
| | | | 129 | 605 | 3.68 | 1.13 |
| | | | 132 | 5061 | 3.67 | 1.52 |
| B997-341PC3 | 66.25 | *Thyasira flexuosa* | 2 | 11682 | 1.80 | -6.78 |
| | | | 3 | 11683 | 2.45 | -5.97 |
| | | | 6 | 14959 | 3.01 | -5.15 |
| | | | 9 | 10008 | 2.77 | -5.14 |
| | | | 10 | 11685 | 2.91 | -5.42 |
| | | | 11 | 11686 | 3.08 | -3.49 |
| | | | 12 | 11117 | 2.56 | -3.50 |
| | | | 14 | 10009 | 2.13 | -4.18 |
| | | | 15 | 11119 | 2.00 | -4.47 |
| | | | 17 | 11687 | 2.05 | -4.26 |
| | | | 18 | 11688 | 2.05 | -4.13 |
| | | | 19 | 10010 | 2.02 | -3.91 |

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|---|---|---|---|
| 20 | 11689 | 2.11 | -3.63 |
| 21 | 11690 | 2.02 | -3.38 |
| 22 | 14964 | 1.90 | -3.16 |
| 24 | 10011 | 2.15 | -3.02 |
| 25 | 11121 | 2.26 | -2.99 |
| 26 | 11122 | 2.31 | -3.17 |
| 27 | 11123 | 2.39 | -3.42 |
| 28 | 10475 | 2.28 | -3.61 |
| 30 | 10471 | 2.43 | -3.84 |
| 32 | 11692 | 2.49 | -4.11 |
| 34 | 10013 | 2.46 | -4.42 |
| 36 | 11694 | 2.51 | -5.19 |
| 39 | 10014 | 2.62 | -5.50 |
| 40 | 11126 | 2.72 | -5.61 |
| 43 | 14965 | 2.09 | -5.00 |
| 44 | 14966 | 1.97 | -4.76 |
| 45 | 10015 | 1.98 | -4.21 |
| 46 | 14967 | 2.02 | -3.94 |
| 47 | 14968 | 1.90 | -3.81 |
| 51 | 14969 | 1.98 | -3.68 |
| 60 | 10018 | 2.51 | -2.53 |
| 61 | 10019 | 2.53 | -3.84 |
| 62 | 11131 | 2.65 | -2.63 |
| 66 | 11698 | 2.35 | -4.90 |
| 67 | 11699 | 2.56 | -4.34 |
| 68 | 10477 | 2.58 | -4.22 |
| 70 | 10025 | 2.31 | -4.60 |
| 71 | 11704 | 2.30 | -4.76 |
| 72 | 11705 | 2.61 | -4.41 |
| 73 | 11706 | 2.57 | -5.23 |
| 75 | 10026 | 2.21 | -5.04 |
| 76 | 10473 | 2.30 | -5.41 |
| 77 | 11707 | 2.34 | -5.47 |
| 80 | 11708 | 2.42 | -5.20 |
| 81 | 10027 | 2.27 | -4.92 |
| 84 | 11134 | 2.02 | -3.99 |
| 87 | 11709 | 2.12 | -3.55 |
| 88 | 11710 | 2.30 | -4.46 |
| 89 | 11711 | 2.30 | -4.72 |
| 90 | 11135 | 2.45 | -4.82 |
| 92 | 10476 | 2.35 | -5.05 |
| 94 | 11136 | 2.57 | -4.85 |

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|---|---|---|---|---|---|---|
| B997-341PC3 | 91.75 | *Thyasira flexuosa* | 5 | 5213 | 1.50 | -4.52 |
| | | | 10 | 5214 | 1.42 | -4.62 |
| | | | 11 | 5234 | 1.36 | -4.39 |
| | | | 19 | 5215 | 1.50 | -4.35 |
| | | | 21 | 5235 | 1.59 | -4.51 |
| | | | 30 | 5216 | 1.40 | -3.91 |
| | | | 31 | 5236 | 1.45 | -3.83 |
| | | | 35 | 5264 | 1.59 | -4.20 |
| | | | 37 | 5679 | 1.69 | -3.96 |
| | | | 40 | 5217 | 1.75 | -3.11 |
| | | | 41 | 5239 | 1.50 | -3.02 |
| | | | 45 | 5680 | 1.45 | -2.68 |
| | | | 46 | 5238 | 1.32 | -3.34 |
| | | | 50 | 5218 | 1.66 | -3.83 |
| | | | 60 | 5219 | 2.20 | -3.05 |
| | | | 61 | 5240 | 2.38 | -2.95 |
| | | | 63 | 731 | 2.41 | -2.95 |
| | | | 65 | 5720 | 2.54 | -2.92 |
| | | | 67 | 5721 | 2.50 | -3.11 |
| | | | 70 | 5220 | 2.29 | -3.14 |
| | | | 72 | 5241 | 2.24 | -3.05 |
| | | | 80 | 5221 | 1.39 | -2.70 |
| | | | 87 | 6658 | 1.34 | -3.39 |
| | | | 93 | 5265 | 1.49 | -4.60 |
| | | | 97 | 5258 | 1.93 | -4.57 |
| | | | 100 | 5223 | 2.18 | -4.54 |
| | | | 102 | 5259 | 2.60 | -4.10 |
| | | | 105 | 607 | 2.70 | -3.34 |
| | | | 106 | 608 | 2.70 | -3.09 |
| | | | 108 | 6660 | 2.93 | -2.62 |
| | | | 109 | 5723 | 2.70 | -2.75 |
| | | | 110 | 5224 | 1.57 | -3.00 |
| | | | 112 | 6688 | 1.93 | -3.62 |
| | | | 119 | 5261 | 2.29 | -4.30 |
| | | | 120 | 5225 | 2.62 | -3.95 |
| | | | 121 | 609 | 1.76 | -3.69 |
| | | | 122 | 610 | 1.53 | -3.50 |
| | | | 123 | 733 | 1.63 | -3.33 |
| | | | 128 | 5724 | 2.49 | -3.84 |
| | | | 129 | 5226 | 2.88 | -3.74 |
| | | | 131 | 6721 | 2.39 | -3.84 |
| | | | 135 | 5262 | 2.49 | -4.52 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 137 | 5263 | 2.56 | -4.48 |
| MD99-2266 | 9.5-10.5 | *Macoma calcarea* | 5 | 10450 | 2.67 | 0.90 |
| | | | 10 | 11142 | 2.90 | 1.22 |
| | | | 14 | 10050 | 3.03 | 1.44 |
| | | | 19 | 10451 | 3.26 | 1.37 |
| | | | 20 | 13879 | 3.49 | 1.42 |
| | | | 21 | 13880 | 3.36 | 1.28 |
| | | | 22 | 13881 | 3.10 | 0.51 |
| | | | 23 | 13882 | 3.18 | 0.83 |
| | | | 24 | 10051 | 3.30 | 0.99 |
| | | | 25 | 10452 | 3.32 | 0.71 |
| | | | 26 | 14866 | 2.73 | -0.08 |
| | | | 27 | 13735 | 2.31 | 0.11 |
| | | | 28 | 13736 | 2.65 | 0.53 |
| | | | 29 | 10453 | 3.02 | 0.75 |
| | | | 30 | 13737 | 3.11 | 1.20 |
| | | | 32 | 11143 | 3.41 | 1.26 |
| | | | 33 | 11144 | 3.52 | 1.27 |
| | | | 34 | 10052 | 3.68 | 1.34 |
| | | | 35 | 11145 | 3.76 | 1.33 |
| | | | 36 | 13738 | 3.91 | 1.30 |
| | | | 37 | 14867 | 3.93 | 1.27 |
| | | | 38 | 14868 | 3.83 | 0.85 |
| | | | 39 | 10454 | 3.09 | 0.29 |
| | | | 40 | 14869 | 2.58 | 0.65 |
| | | | 41 | 14870 | 2.54 | 1.13 |
| | | | 42 | 14871 | 2.52 | 1.25 |
| | | | 43 | 13739 | 2.36 | 1.26 |
| | | | 45 | 10455 | 2.58 | 1.53 |
| | | | 46 | 13740 | 2.58 | 1.63 |
| | | | 50 | 10456 | 2.59 | 1.62 |
| | | | 55 | 10457 | 2.64 | 1.64 |
| | | | 56 | 2358 | 2.75 | 1.53 |
| | | | 57 | 2359 | 2.73 | 1.41 |
| | | | 58 | 1076 | 3.07 | 1.41 |
| | | | 59 | 2360 | 2.72 | 1.36 |
| | | | 60 | 10458 | 2.73 | 1.34 |
| | | | 61 | 1178 | 2.96 | 1.47 |
| | | | 62 | 2361 | 2.89 | 1.46 |
| | | | 64 | 10055 | 2.70 | 1.36 |
| | | | 69 | 10459 | 2.73 | 1.34 |
| | | | 73 | 10056 | 2.80 | 1.17 |

| | | | |
|---|---|---|---|
| 74 | 1179 | 3.02 | 1.33 |
| 75 | 1062 | 2.98 | 1.37 |
| 76 | 1063 | 2.98 | 1.39 |
| 77 | 14872 | 3.40 | 1.64 |
| 78 | 1064 | 3.06 | 1.47 |
| 79 | 1065 | 3.13 | 1.46 |
| 81 | 1066 | 3.07 | 1.38 |
| 82 | 1067 | 3.12 | 1.37 |
| 83 | 10057 | 3.03 | 1.28 |
| 84 | 1068 | 3.13 | 1.33 |
| 85 | 1069 | 3.20 | 1.39 |
| 86 | 1070 | 3.19 | 1.39 |
| 87 | 14873 | 3.57 | 1.61 |
| 88 | 13741 | 3.37 | 1.53 |
| 89 | 14874 | 3.57 | 1.62 |
| 90 | 1071 | 3.37 | 1.46 |
| 92 | 1072 | 3.24 | 1.44 |
| 93 | 10058 | 3.16 | 1.32 |
| 94 | 1073 | 3.27 | 1.39 |
| 98 | 13742 | 3.60 | 1.50 |
| 102 | 11146 | 3.68 | 1.44 |
| 104 | 10059 | 3.85 | 1.50 |
| 105 | 11147 | 3.76 | 1.33 |
| 106 | 10460 | 3.84 | 0.93 |
| 107 | 13743 | 3.57 | 0.46 |
| 108 | 13744 | 2.50 | 0.22 |
| 109 | 13745 | 2.34 | 0.49 |
| 110 | 13750 | 2.35 | 0.70 |
| 111 | 13751 | 2.68 | 1.03 |
| 112 | 11148 | 2.61 | 1.13 |
| 113 | 10060 | 2.78 | 1.25 |
| 114 | 11149 | 2.91 | 1.23 |
| 119 | 1074 | 3.66 | 1.33 |
| 120 | 1075 | 3.64 | 1.36 |
| 122 | 13753 | 3.50 | 1.52 |
| 123 | 10061 | 3.50 | 1.52 |
| 124 | 13754 | 3.74 | 1.69 |
| 125 | 13755 | 3.38 | 1.57 |
| 129 | 13756 | 3.19 | 1.41 |
| 131 | 11150 | 3.21 | 1.55 |
| 134 | 13757 | 3.17 | 1.51 |
| 140 | 10467 | 2.49 | 0.69 |
| 142 | 11192 | 2.59 | 0.59 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 143 | 10063 | 2.55 | 0.87 |
| | | | 144 | 11193 | 2.55 | 0.70 |
| | | | 152 | 11194 | 3.68 | 1.35 |
| | | | 153 | 10064 | 3.87 | 1.53 |
| | | | 154 | 11195 | 2.83 | 0.91 |
| | | | 158 | 14889 | 3.13 | 1.10 |
| | | | 159 | 10468 | 2.73 | 1.39 |
| | | | 161 | 13759 | 2.60 | 1.35 |
| | | | 162 | 13760 | 2.63 | 1.36 |
| | | | 163 | 10065 | 2.71 | 1.33 |
| | | | 164 | 11196 | 2.80 | 1.23 |
| | | | 165 | 11197 | 2.89 | 1.33 |
| | | | 167 | 13761 | 2.97 | 1.39 |
| | | | 168 | 13762 | 2.90 | 1.29 |
| | | | 172 | 13763 | 3.12 | 1.40 |
| | | | 173 | 10066 | 3.15 | 1.40 |
| | | | 175 | 13764 | 3.28 | 1.33 |
| | | | 182 | 13765 | 3.57 | 1.12 |
| | | | 183 | 10067 | 3.70 | 1.02 |
| | | | 184 | 13766 | 3.09 | 0.40 |
| | | | 188 | 10441 | 2.73 | 0.75 |
| | | | 189 | 11199 | 2.64 | 0.77 |
| | | | 190 | 13767 | 2.72 | 1.00 |
| | | | 193 | 10442 | 2.84 | 1.29 |
| | | | 198 | 10443 | 3.09 | 0.93 |
| | | | 199 | 10470 | 3.19 | 0.85 |
| | | | 203 | 13768 | 3.46 | 1.11 |
| | | | 204 | 10444 | 3.51 | 0.98 |
| | | | 207 | 14891 | 3.04 | 0.76 |
| | | | 208 | 14892 | 2.87 | 1.00 |
| | | | 210 | 14893 | 3.11 | 1.05 |
| | | | 211 | 14894 | 3.03 | 1.12 |
| | | | 212 | 14895 | 2.96 | 1.22 |
| | | | 213 | 14896 | 2.95 | 1.26 |
| | | | 214 | 10446 | 3.04 | 1.29 |
| | | | 215 | 14897 | 3.23 | 1.28 |
| | | | 216 | 14898 | 3.48 | 1.29 |
| | | | 217 | 14899 | 3.46 | 1.19 |
| | | | 218 | 13874 | 3.69 | 1.23 |
| | | | 220 | 13875 | 3.57 | 1.22 |
| MD99-2266 | 24-25 | *Thyasira flexuosa* | 0 | 13602 | 3.06 | -3.29 |
| | | | 2 | 2363 | 3.04 | -3.05 |

| | | | |
|---|---|---|---|
| 3 | 2364 | 2.83 | -3.22 |
| 4 | 2365 | 2.88 | -3.07 |
| 5 | 13603 | 3.12 | -2.87 |
| 6 | 2366 | 2.77 | -2.99 |
| 7 | 1095 | 3.24 | -2.39 |
| 8 | 1183 | 2.76 | -2.95 |
| 9 | 15042 | 2.99 | -2.91 |
| 10 | 13604 | 3.20 | -2.67 |
| 11 | 15043 | 2.98 | -2.76 |
| 12 | 1184 | 2.90 | -2.74 |
| 13 | 1185 | 2.74 | -2.71 |
| 14 | 2368 | 2.70 | -2.61 |
| 15 | 13605 | 3.17 | -2.32 |
| 19 | 15044 | 2.97 | -2.42 |
| 20 | 13606 | 3.16 | -2.26 |
| 21 | 15045 | 2.88 | -2.48 |
| 22 | 1186 | 2.78 | -2.40 |
| 23 | 1187 | 2.74 | -2.38 |
| 24 | 2367 | 2.69 | -2.39 |
| 25 | 13607 | 3.15 | -2.13 |
| 26 | 2374 | 2.65 | -2.28 |
| 27 | 2375 | 2.63 | -2.21 |
| 28 | 1180 | 2.69 | -2.26 |
| 29 | 15046 | 2.88 | -2.24 |
| 30 | 13608 | 3.19 | -2.05 |
| 31 | 15047 | 2.91 | -2.22 |
| 32 | 1181 | 2.62 | -2.28 |
| 33 | 2376 | 2.70 | -2.28 |
| 35 | 13609 | 2.90 | -2.20 |
| 40 | 13610 | 2.84 | -2.03 |
| 45 | 13611 | 2.85 | -1.88 |
| 50 | 13612 | 2.83 | -1.85 |
| 55 | 13613 | 2.84 | -1.73 |
| 60 | 13614 | 2.66 | -1.61 |
| 65 | 13615 | 2.46 | -1.74 |
| 70 | 13616 | 2.53 | -1.51 |
| 75 | 13617 | 2.50 | -1.55 |
| 80 | 13618 | 2.33 | -1.64 |
| 85 | 13619 | 2.28 | -1.62 |
| 89 | 14876 | 2.40 | -1.47 |
| 90 | 13620 | 2.41 | -1.59 |
| 91 | 14877 | 2.47 | -1.48 |
| 95 | 13703 | 2.16 | -1.63 |

| | | | |
|---|---|---|---|
| 100 | 13704 | 2.22 | -1.62 |
| 105 | 13705 | 2.19 | -1.51 |
| 106 | 1086 | 2.33 | -1.50 |
| 107 | 1182 | 2.30 | -1.51 |
| 108 | 15048 | 2.38 | -1.46 |
| 109 | 15049 | 2.37 | -1.45 |
| 110 | 13706 | 2.04 | -1.60 |
| 111 | 1085 | 2.28 | -1.50 |
| 114 | 1089 | 2.35 | -1.43 |
| 115 | 13707 | 2.16 | -1.64 |
| 115 | 1088 | 2.39 | -1.48 |
| 117 | 2377 | 2.28 | -1.45 |
| 119 | 2378 | 2.32 | -1.45 |
| 120 | 13708 | 2.11 | -1.56 |
| 125 | 13709 | 2.13 | -1.61 |
| 130 | 13710 | 2.32 | -1.66 |
| 135 | 13711 | 2.25 | -1.68 |
| 140 | 13712 | 2.29 | -1.74 |
| 145 | 13713 | 2.40 | -1.85 |
| 150 | 13714 | 2.57 | -1.86 |
| 155 | 13715 | 2.73 | -1.83 |
| 160 | 13716 | 2.83 | -1.79 |
| 164 | 14878 | 3.19 | -1.63 |
| 170 | 13718 | 3.16 | -1.80 |
| 174 | 14879 | 3.35 | -1.84 |
| 175 | 13719 | 2.97 | -2.22 |
| 176 | 14880 | 3.49 | -1.86 |
| 180 | 13720 | 3.29 | -2.02 |
| 185 | 13721 | 3.34 | -1.77 |
| 187 | 1090 | 3.32 | -1.57 |
| 188 | 1091 | 3.52 | -1.75 |
| 189 | 14881 | 3.56 | -1.60 |
| 190 | 13647 | 3.49 | -1.32 |
| 191 | 14882 | 3.56 | -1.52 |
| 192 | 1092 | 3.38 | -1.62 |
| 193 | 1093 | 3.40 | -1.55 |
| 194 | 1094 | 3.38 | -1.53 |
| 195 | 13648 | 3.33 | -1.01 |
| 216 | 13652 | 3.26 | -0.68 |
| 221 | 13657 | 2.99 | -0.93 |
| 225 | 13658 | 2.90 | -0.97 |
| 230 | 13659 | 2.61 | -0.75 |
| 235 | 13660 | 2.46 | -0.59 |

| | | | |
|---|---|---|---|
| 240 | 13661 | 2.40 | -0.54 |
| 250 | 13663 | 2.29 | -0.51 |
| 251 | 2379 | 2.21 | -0.65 |
| 252 | 2380 | 2.04 | -0.77 |
| 253 | 14883 | 2.47 | -0.51 |
| 254 | 14526 | 2.16 | -0.73 |
| 255 | 13664 | 2.18 | -0.71 |
| 256 | 14527 | 2.24 | -0.73 |
| 257 | 14528 | 2.29 | -0.72 |
| 258 | 14529 | 2.28 | -0.59 |
| 259 | 14530 | 2.40 | -0.56 |
| 260 | 13665 | 2.50 | -0.50 |
| 261 | 14531 | 2.30 | -0.36 |
| 262 | 14532 | 2.27 | -0.31 |
| 263 | 14533 | 2.20 | -0.19 |
| 264 | 14534 | 2.20 | -0.10 |
| 265 | 13666 | 2.37 | -0.22 |
| 266 | 14535 | 2.54 | 0.02 |
| 267 | 14536 | 2.30 | -0.07 |
| 268 | 14537 | 2.23 | -0.13 |
| 269 | 14538 | 2.11 | -0.12 |
| 270 | 13667 | 2.21 | -0.11 |
| 271 | 14539 | 2.15 | -0.11 |
| 272 | 14884 | 2.50 | 0.08 |
| 273 | 2381 | 2.21 | -0.14 |
| 274 | 2382 | 2.24 | -0.12 |
| 275 | 13668 | 2.36 | -0.05 |
| 280 | 13669 | 2.66 | 0.13 |
| 285 | 13670 | 2.45 | -0.12 |
| 290 | 13671 | 2.93 | -0.45 |
| 295 | 13672 | 3.08 | -0.52 |
| 297 | 14544 | 3.17 | -0.54 |
| 298 | 14540 | 3.30 | -0.77 |
| 300 | 13673 | 3.62 | -1.22 |
| 302 | 14541 | 3.57 | -1.32 |
| 303 | 14542 | 3.65 | -1.02 |
| 304 | 14543 | 3.66 | -1.14 |
| 305 | 13674 | 3.54 | -1.11 |
| 310 | 13675 | 3.04 | -0.31 |
| 315 | 14519 | 2.52 | -0.56 |
| 321 | 14520 | 2.53 | -0.33 |
| 322 | 1188 | 2.13 | -0.28 |
| 323 | 1102 | 2.35 | -0.29 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 324 | 1103 | 2.15 | -0.56 |
| | | | 325 | 14521 | 2.12 | -1.44 |
| MD99-2266 | 26-26.5 | *Astarte cf. castanea* | 2 | 908 | 2.47 | 1.29 |
| | | | 3 | 909 | 2.51 | 1.44 |
| | | | 6 | 910 | 2.74 | 2.08 |
| | | | 7 | 2792 | 2.41 | 1.98 |
| | | | 8 | 911 | 2.90 | 2.13 |
| | | | 9 | 613 | 2.55 | 1.77 |
| | | | 10 | 2793 | 2.54 | 1.85 |
| | | | 11 | 2794 | 2.44 | 1.82 |
| | | | 12 | 2795 | 2.64 | 1.89 |
| | | | 13 | 2796 | 2.54 | 1.93 |
| | | | 14 | 614 | 2.67 | 1.85 |
| | | | 19 | 615 | 2.71 | 2.23 |
| | | | 24 | 616 | 2.77 | 2.38 |
| | | | 29 | 617 | 2.71 | 2.12 |
| | | | 34 | 618 | 2.72 | 1.86 |
| | | | 39 | 619 | 2.71 | 2.04 |
| | | | 44 | 620 | 2.84 | 2.00 |
| | | | 49 | 621 | 2.81 | 1.90 |
| | | | 54 | 622 | 2.76 | 1.85 |
| | | | 59 | 623 | 2.82 | 1.99 |
| | | | 64 | 624 | 2.92 | 2.28 |
| | | | 69 | 625 | 2.94 | 1.98 |
| | | | 74 | 626 | 2.84 | 1.74 |
| | | | 79 | 627 | 2.93 | 1.56 |
| | | | 84 | 628 | 3.07 | 1.65 |
| | | | 89 | 629 | 3.06 | 1.51 |
| | | | 94 | 634 | 3.06 | 1.64 |
| | | | 99 | 635 | 3.13 | 1.66 |
| | | | 104 | 636 | 3.20 | 1.54 |
| | | | 109 | 637 | 3.38 | 1.44 |
| | | | 114 | 638 | 3.44 | 1.29 |
| | | | 115 | 912 | 3.60 | 1.54 |
| | | | 116 | 913 | 3.86 | 1.11 |
| | | | 117 | 914 | 3.51 | 1.39 |
| | | | 118 | 915 | 3.51 | 1.28 |
| | | | 119 | 639 | 3.46 | 0.77 |
| | | | 120 | 916 | 3.76 | 1.04 |
| | | | 121 | 917 | 3.63 | 1.00 |
| | | | 122 | 2797 | 3.21 | 0.77 |
| | | | 123 | 2798 | 3.26 | 0.74 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 124 | 640 | 3.30 | 0.44 |
| | | | 130 | 641 | 2.85 | 0.26 |
| | | | 131 | 2706 | 2.54 | 0.20 |
| | | | 132 | 2711 | 2.44 | 0.34 |
| | | | 133 | 918 | 2.43 | 0.50 |
| | | | 134 | 642 | 2.37 | 0.76 |
| | | | 135 | 919 | 2.48 | 0.85 |
| | | | 139 | 643 | 2.52 | 0.89 |
| | | | 144 | 644 | 2.44 | 0.65 |
| | | | 149 | 645 | 2.52 | 0.59 |
| | | | 154 | 646 | 2.55 | 0.71 |
| | | | 159 | 647 | 2.43 | 0.68 |
| | | | 164 | 1290 | 2.69 | 0.65 |
| | | | 169 | 1291 | 2.74 | 0.39 |
| | | | 174 | 1292 | 2.89 | 0.62 |
| | | | 179 | 1293 | 2.93 | 1.09 |
| | | | 184 | 1294 | 2.98 | 1.21 |
| | | | 189 | 1295 | 2.91 | 1.09 |
| | | | 194 | 1296 | 3.07 | 0.97 |
| | | | 199 | 1297 | 3.11 | 0.98 |
| | | | 210 | 2700 | 3.00 | 0.79 |
| | | | 220 | 2701 | 3.29 | 0.40 |
| | | | 230 | 2702 | 3.64 | 0.71 |
| | | | 231 | 2703 | 3.70 | 0.86 |
| | | | 232 | 2704 | 3.74 | 0.86 |
| | | | 233 | 2705 | 3.23 | 0.54 |
| | | | 235 | 2707 | 3.35 | 1.06 |
| | | | 236 | 2708 | 3.13 | 1.18 |
| | | | 240 | 2709 | 3.04 | 1.40 |
| | | | 247 | 2710 | 3.75 | 1.22 |
| MD99-2266 | 46.5-47.5 | *Nuculana tenuisulacata* | 0 | 2683 | 3.21 | 0.76 |
| | | | 1 | 2684 | 3.25 | 0.78 |
| | | | 2 | 2685 | 3.50 | 0.76 |
| | | | 3 | 2686 | 3.66 | 0.66 |
| | | | 4 | 2744 | 3.97 | 0.88 |
| | | | 5 | 2745 | 4.11 | 0.99 |
| | | | 6 | 2787 | 4.03 | 1.07 |
| | | | 7 | 2788 | 3.82 | 1.10 |
| | | | 10 | 2687 | 3.08 | 1.10 |
| | | | 17 | 2789 | 2.76 | 0.54 |
| | | | 18 | 2790 | 2.79 | 0.59 |

| | | | |
|---|---|---|---|
| 19 | 2746 | 2.92 | 0.57 |
| 20 | 2688 | 2.74 | 0.53 |
| 21 | 2747 | 2.95 | 0.55 |
| 30 | 2689 | 3.15 | 0.87 |
| 37 | 2791 | 3.68 | 0.67 |
| 38 | 2792 | 3.80 | 0.79 |
| 39 | 2748 | 4.00 | 0.92 |
| 40 | 2690 | 3.80 | 0.92 |
| 41 | 2793 | 3.94 | 1.13 |
| 48 | 2794 | 2.86 | 1.45 |
| 49 | 2798 | 2.82 | 1.42 |
| 50 | 2691 | 2.67 | 1.32 |
| 51 | 2799 | 2.73 | 1.11 |
| 52 | 2800 | 2.75 | 1.10 |
| 60 | 2692 | 2.97 | 0.77 |
| 68 | 2801 | 3.65 | 0.95 |
| 69 | 2802 | 3.74 | 1.03 |
| 70 | 2693 | 3.59 | 0.94 |
| 71 | 2803 | 3.70 | 1.02 |
| 80 | 2694 | 2.78 | 1.01 |
| 85 | 2807 | 2.77 | 1.17 |
| 88 | 2816 | 2.75 | 1.08 |
| 89 | 2805 | 2.78 | 1.10 |
| 90 | 2695 | 2.75 | 1.07 |
| 91 | 2806 | 2.77 | 1.12 |
| 92 | 2817 | 2.78 | 1.13 |
| 95 | 2808 | 2.79 | 1.16 |
| 100 | 2696 | 2.77 | 1.05 |
| 110 | 2682 | 3.04 | 1.13 |
| 120 | 2713 | 3.27 | 0.93 |
| 130 | 2714 | 3.57 | 0.48 |
| 132 | 2809 | 3.66 | 0.50 |
| 134 | 2810 | 3.64 | 0.57 |
| 135 | 3542 | 3.84 | 0.77 |
| 136 | 2811 | 3.86 | 0.77 |
| 137 | 3543 | 3.96 | 0.88 |
| 140 | 2715 | 3.51 | 1.15 |
| 148 | 2812 | 3.06 | 1.02 |
| 149 | 2813 | 3.10 | 1.11 |
| 150 | 2716 | 2.87 | 0.98 |
| 151 | 2814 | 2.83 | 0.93 |
| 152 | 2815 | 2.87 | 1.00 |
| 159 | 2719 | 3.04 | 1.34 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 160 | 2717 | 3.30 | 1.43 |
| | | | 161 | 2718 | 3.46 | 1.73 |
| MD99-2266 | 53 | *Tellina tenuis* | 0 | 2654 | 3.11 | 1.28 |
| | | | 2 | 2656 | 3.05 | 1.37 |
| | | | 4 | 2657 | 2.99 | 1.33 |
| | | | 5 | 2658 | 3.11 | 1.45 |
| | | | 6 | 2659 | 2.95 | 1.29 |
| | | | 7 | 2660 | 2.91 | 1.30 |
| | | | 8 | 2661 | 3.02 | 1.31 |
| | | | 10 | 2662 | 2.87 | 1.24 |
| | | | 13 | 2775 | 3.08 | 1.29 |
| | | | 20 | 2663 | 2.96 | 1.14 |
| | | | 25 | 2777 | 3.17 | 1.23 |
| | | | 30 | 2664 | 3.24 | 1.16 |
| | | | 31 | 2665 | 3.34 | 1.19 |
| | | | 32 | 2666 | 3.46 | 1.22 |
| | | | 33 | 2667 | 3.30 | 1.13 |
| | | | 34 | 2668 | 3.28 | 1.08 |
| | | | 35 | 2669 | 3.29 | 1.07 |
| | | | 37 | 3541 | 3.41 | 0.92 |
| | | | 39 | 3540 | 3.28 | 0.81 |
| | | | 40 | 2670 | 3.24 | 0.73 |
| | | | 41 | 2732 | 3.35 | 0.74 |
| | | | 43 | 2734 | 3.47 | 0.86 |
| | | | 44 | 2735 | 3.48 | 0.84 |
| | | | 49 | 2671 | 3.58 | 0.91 |
| | | | 50 | 2672 | 3.59 | 0.86 |
| | | | 51 | 2673 | 3.59 | 0.83 |
| | | | 53 | 2677 | 3.69 | 0.79 |
| | | | 54 | 2778 | 3.74 | 0.81 |
| | | | 55 | 2779 | 3.93 | 0.88 |
| | | | 56 | 2780 | 4.09 | 0.58 |
| | | | 57 | 2781 | 4.19 | 0.48 |
| | | | 58 | 2736 | 4.23 | 0.54 |
| | | | 59 | 2737 | 4.09 | 0.57 |
| | | | 60 | 2678 | 3.88 | 0.61 |
| | | | 61 | 2738 | 3.71 | 0.75 |
| | | | 62 | 2739 | 3.43 | 0.82 |
| | | | 63 | 2782 | 3.13 | 0.74 |
| | | | 67 | 2786 | 3.20 | 0.35 |
| | | | 68 | 2740 | 3.35 | 0.63 |
| | | | 69 | 2741 | 3.37 | 0.78 |

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|---|---|---|---|---|---|---|
| | | | 70 | 2679 | 3.28 | 1.01 |
| | | | 71 | 2742 | 3.54 | 1.10 |
| | | | 72 | 2743 | 3.49 | 0.93 |
| | | | 73 | 2680 | 3.57 | 0.65 |
| | | | 75 | 2681 | 3.73 | 0.42 |
| MD99-2266 | 72-74 | *Thyasira flexuosa* | 0 | 3244 | 1.85 | -7.39 |
| | | | 1 | 3245 | 2.23 | -6.96 |
| | | | 2 | 3246 | 2.76 | -5.95 |
| | | | 4 | 3516 | 2.72 | -7.09 |
| | | | 9 | 3517 | 1.79 | -7.12 |
| | | | 10 | 3247 | 1.89 | -6.37 |
| | | | 11 | 3518 | 2.11 | -5.88 |
| | | | 20 | 3248 | 2.49 | -5.33 |
| | | | 30 | 3249 | 2.40 | -5.12 |
| | | | 40 | 3250 | 2.73 | -4.19 |
| | | | 50 | 3251 | 2.81 | -4.01 |
| | | | 60 | 3252 | 3.20 | -3.64 |
| | | | 70 | 3253 | 3.29 | -3.52 |
| | | | 80 | 3254 | 3.32 | -3.36 |
| | | | 89 | 3519 | 3.19 | -3.18 |
| | | | 91 | 3520 | 2.97 | -3.35 |
| | | | 100 | 3256 | 3.30 | -3.33 |
| | | | 110 | 3257 | 2.68 | -4.10 |
| | | | 119 | 3521 | 2.37 | -4.53 |
| | | | 120 | 3258 | 2.42 | -4.31 |
| | | | 121 | 3522 | 2.48 | -4.18 |
| | | | 130 | 3259 | 2.56 | -4.02 |
| | | | 140 | 3260 | 2.92 | -3.58 |
| | | | 150 | 3261 | 3.30 | -3.27 |
| | | | 160 | 3262 | 3.61 | -2.81 |
| | | | 169 | 3523 | 3.62 | -2.74 |
| | | | 170 | 3263 | 3.68 | -2.84 |
| | | | 171 | 3524 | 3.62 | -2.70 |
| | | | 179 | 3525 | 3.64 | -2.76 |
| | | | 180 | 3317 | 3.57 | -3.05 |
| | | | 181 | 3526 | 3.65 | -2.79 |
| | | | 210 | 3350 | 2.40 | -4.49 |
| | | | 219 | 3539 | 2.54 | -3.67 |
| | | | 220 | 3351 | 2.36 | -3.71 |
| | | | 230 | 3352 | 2.43 | -3.20 |
| | | | 240 | 3353 | 2.67 | -2.61 |
| | | | 242 | 3527 | 2.83 | -2.45 |

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|---|---|---|---|---|---|---|
| | | | 244 | 3531 | 2.93 | -2.13 |
| | | | 246 | 3532 | 2.90 | -1.98 |
| | | | 248 | 3533 | 2.80 | -1.98 |
| | | | 250 | 3354 | 2.64 | -2.49 |
| | | | 259 | 3534 | 2.41 | -3.62 |
| | | | 260 | 3355 | 2.33 | -3.59 |
| | | | 261 | 3535 | 2.41 | -3.68 |
| | | | 270 | 3356 | 2.46 | -3.50 |
| | | | 280 | 3357 | 2.42 | -3.25 |
| | | | 290 | 3358 | 2.66 | -3.06 |
| | | | 300 | 3359 | 2.99 | -2.81 |
| | | | 310 | 3360 | 3.18 | -2.77 |
| | | | 320 | 3361 | 3.33 | -2.56 |
| | | | 330 | 3362 | 3.37 | -2.40 |
| | | | 334 | 3536 | 3.32 | -2.42 |
| | | | 335 | 3537 | 3.34 | -2.42 |
| | | | 336 | 3538 | 3.36 | -2.38 |
| | | | 340 | 3363 | 3.36 | -2.42 |
| | | | 350 | 3364 | 3.36 | -2.30 |
| | | | 360 | 3365 | 3.20 | -2.30 |
| | | | 370 | 3366 | 2.95 | -2.32 |
| | | | 380 | 3508 | 2.84 | -2.34 |
| | | | 390 | 3509 | 2.84 | -2.32 |
| | | | 400 | 3510 | 2.59 | -2.37 |
| | | | 410 | 3511 | 2.65 | -2.22 |
| | | | 420 | 3512 | 2.49 | -2.24 |
| | | | 430 | 3513 | 2.63 | -2.04 |
| | | | 439 | 3514 | 2.52 | -2.05 |
| MD99-2266 | 90-92 | *Nuculana tenuisulcata* | 0 | 4046 | 3.06 | 0.96 |
| | | | 1 | 4047 | 3.05 | 1.01 |
| | | | 2 | 4048 | 2.95 | 1.01 |
| | | | 4 | 4275 | 3.03 | 1.01 |
| | | | 5 | 4049 | 2.93 | 0.98 |
| | | | 6 | 4276 | 3.07 | 1.11 |
| | | | 9 | 4277 | 3.08 | 1.02 |
| | | | 10 | 4050 | 3.03 | 1.02 |
| | | | 11 | 4278 | 3.07 | 1.00 |
| | | | 20 | 4051 | 2.97 | 0.56 |
| | | | 30 | 4052 | 2.94 | 0.93 |
| | | | 39 | 4279 | 2.97 | 0.98 |
| | | | 40 | 1041 | 3.06 | 1.15 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 41 | 4336 | 3.14 | 1.00 |
| | | | 42 | 4337 | 3.15 | 1.00 |
| | | | 45 | 4280 | 3.03 | 1.08 |
| | | | 50 | 4054 | 3.03 | 0.85 |
| | | | 60 | 4055 | 3.03 | 0.80 |
| | | | 70 | 4056 | 3.08 | 0.66 |
| | | | 74 | 4338 | 3.35 | 0.54 |
| | | | 75 | 4281 | 3.24 | 0.36 |
| | | | 76 | 4339 | 3.28 | 0.38 |
| | | | 80 | 4057 | 3.12 | 0.47 |
| | | | 85 | 4282 | 2.97 | 0.84 |
| | | | 90 | 4058 | 2.88 | 1.01 |
| | | | 99 | 4340 | 2.69 | 0.93 |
| | | | 100 | 4059 | 2.76 | 0.89 |
| | | | 101 | 4341 | 2.88 | 0.86 |
| | | | 109 | 4283 | 2.90 | 0.43 |
| | | | 110 | 4060 | 2.84 | 0.35 |
| | | | 111 | 4284 | 2.97 | 0.48 |
| | | | 120 | 4288 | 3.01 | 0.58 |
| | | | 135 | 4289 | 3.02 | 0.51 |
| | | | 150 | 4290 | 3.36 | -0.12 |
| | | | 164 | 4342 | 3.64 | 0.32 |
| | | | 165 | 4291 | 3.62 | 0.37 |
| | | | 166 | 4343 | 3.68 | 0.39 |
| | | | 170 | 1086 | 3.99 | 0.30 |
| | | | 180 | 4292 | 3.21 | 0.62 |
| | | | 190 | 4344 | 2.85 | 0.55 |
| | | | 193 | 4345 | 2.89 | 0.36 |
| | | | 195 | 4293 | 2.70 | 0.33 |
| | | | 210 | 4294 | 2.72 | 0.17 |
| | | | 225 | 4295 | 2.72 | -0.07 |
| | | | 240 | 4296 | 2.79 | -0.29 |
| | | | 255 | 4297 | 2.89 | -0.53 |
| | | | 270 | 4298 | 2.96 | -0.62 |
| | | | 285 | 4299 | 3.22 | -1.30 |
| | | | 298 | 1050 | 3.20 | -0.91 |
| | | | 300 | 4300 | 3.45 | -1.06 |
| | | | 316 | 4346 | 3.30 | 0.86 |
| | | | 320 | 4347 | 3.40 | 0.84 |
| MD99-2266 | 112-113.5 | *Thyasira flexuosa* | 0 | 8283 | 2.39 | -4.51 |
| | | | 4 | 8284 | 2.18 | -4.81 |
| | | | 6 | 8285 | 2.26 | -4.80 |

| | | | |
|---|---|---|---|
| 8 | 8286 | 2.01 | -4.82 |
| 9 | 8287 | 2.12 | -4.65 |
| 11 | 8288 | 1.88 | -4.96 |
| 14 | 9171 | 2.07 | -4.87 |
| 15 | 8677 | 1.85 | -4.96 |
| 16 | 9172 | 1.89 | -4.91 |
| 17 | 9173 | 1.96 | -4.92 |
| 18 | 9174 | 1.96 | -4.87 |
| 19 | 9175 | 2.00 | -4.86 |
| 20 | 8678 | 1.83 | -4.83 |
| 21 | 9176 | 2.08 | -4.69 |
| 22 | 9177 | 2.01 | -4.76 |
| 23 | 9178 | 2.08 | -4.72 |
| 24 | 9179 | 1.96 | -4.83 |
| 25 | 8679 | 1.87 | -4.82 |
| 27 | 9180 | 2.00 | -4.59 |
| 29 | 9181 | 2.02 | -4.51 |
| 31 | 9182 | 2.26 | -4.55 |
| 33 | 9183 | 2.24 | -4.80 |
| 34 | 8680 | 2.14 | -4.95 |
| 35 | 9184 | 2.27 | -5.01 |
| 37 | 9186 | 2.33 | -5.04 |
| 38 | 9187 | 2.32 | -4.87 |
| 40 | 9188 | 2.35 | -4.89 |
| 41 | 9189 | 2.47 | -4.71 |
| 41 | 9190 | 2.60 | -4.84 |
| 43 | 9194 | 2.51 | -5.01 |
| 44 | 8682 | 2.36 | -4.96 |
| 45 | 9195 | 2.59 | -4.90 |
| 47 | 9196 | 2.75 | -4.64 |
| 48 | 9197 | 2.65 | -4.57 |
| 49 | 8683 | 2.53 | -4.55 |
| 50 | 9198 | 2.67 | -4.46 |
| 51 | 9199 | 2.75 | -4.41 |
| 52 | 9200 | 2.79 | -4.46 |
| 53 | 9201 | 2.81 | -4.50 |
| 54 | 8684 | 2.82 | -4.57 |
| 55 | 9202 | 2.77 | -4.47 |
| 56 | 9203 | 2.79 | -4.52 |
| 57 | 9204 | 2.84 | -4.54 |
| 58 | 9205 | 2.88 | -4.42 |
| 59 | 8685 | 2.98 | -4.54 |
| 61 | 9206 | 3.00 | -4.41 |

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|---|---|---|---|
| 62 | 9207 | 3.15 | -4.30 |
| 63 | 9208 | 3.06 | -4.48 |
| 64 | 9209 | 3.02 | -4.56 |
| 65 | 8686 | 3.03 | -4.57 |
| 66 | 9210 | 3.12 | -4.43 |
| 67 | 9211 | 3.13 | -4.37 |
| 68 | 9212 | 3.18 | -4.34 |
| 69 | 9213 | 3.20 | -4.28 |
| 70 | 8687 | 3.25 | -4.34 |
| 71 | 9217 | 3.13 | -4.26 |
| 72 | 9218 | 3.08 | -4.24 |
| 73 | 9219 | 2.97 | -4.23 |
| 74 | 9220 | 2.88 | -4.20 |
| 75 | 8688 | 3.05 | -4.22 |
| 76 | 9221 | 2.83 | -4.19 |
| 77 | 9222 | 2.91 | -4.16 |
| 78 | 9223 | 2.96 | -4.13 |
| 79 | 9224 | 2.84 | -4.11 |
| 80 | 8689 | 2.90 | -4.13 |
| 81 | 9225 | 2.75 | -4.08 |
| 82 | 9226 | 2.79 | -4.14 |
| 83 | 9227 | 2.71 | -4.06 |
| 84 | 9228 | 2.74 | -4.10 |
| 85 | 8690 | 2.78 | -4.12 |
| 86 | 9229 | 2.71 | -4.18 |
| 87 | 9230 | 2.61 | -4.19 |
| 88 | 9231 | 2.50 | -4.23 |
| 89 | 9232 | 2.40 | -4.27 |
| 91 | 9233 | 2.42 | -4.36 |
| 92 | 9234 | 2.35 | -4.34 |
| 93 | 9235 | 2.37 | -4.26 |
| 95 | 8692 | 2.48 | -4.31 |
| 96 | 9240 | 2.41 | -4.24 |
| 97 | 9241 | 2.34 | -4.28 |
| 98 | 9242 | 2.44 | -4.22 |
| 99 | 9243 | 2.42 | -4.26 |
| 100 | 8693 | 2.45 | -4.31 |
| 101 | 9244 | 2.33 | -4.26 |
| 102 | 9245 | 2.32 | -4.28 |
| 103 | 9246 | 2.34 | -4.25 |
| 104 | 9247 | 2.32 | -4.25 |
| 105 | 8694 | 2.48 | -4.24 |
| 107 | 9259 | 2.46 | -4.19 |

| | | | |
|---|---|---|---|
| 108 | 9260 | 2.21 | -4.27 |
| 109 | 9261 | 2.40 | -4.20 |
| 110 | 8695 | 2.43 | -4.24 |
| 111 | 9262 | 2.19 | -4.23 |
| 112 | 9263 | 2.25 | -4.16 |
| 113 | 9264 | 2.51 | -4.01 |
| 114 | 9265 | 2.44 | -3.96 |
| 115 | 8696 | 2.47 | -4.01 |
| 116 | 9266 | 2.55 | -4.25 |
| 117 | 9267 | 2.51 | -4.35 |
| 118 | 9268 | 2.68 | -4.32 |
| 119 | 8697 | 2.64 | -4.52 |
| 120 | 9269 | 2.67 | -4.11 |
| 121 | 9270 | 2.61 | -4.49 |
| 122 | 9271 | 2.78 | -4.37 |
| 123 | 9272 | 2.56 | -4.52 |
| 124 | 8700 | 2.76 | -4.62 |
| 125 | 9273 | 2.62 | -4.47 |
| 126 | 9274 | 2.61 | -4.42 |
| 127 | 9275 | 2.66 | -4.37 |
| 128 | 9276 | 2.80 | -4.27 |
| 129 | 8701 | 2.78 | -4.35 |
| 130 | 9277 | 2.69 | -4.28 |
| 131 | 9278 | 2.75 | -4.28 |
| 132 | 9282 | 2.66 | -4.14 |
| 133 | 9283 | 2.81 | -4.22 |
| 134 | 8702 | 2.41 | -4.55 |
| 135 | 9284 | 2.64 | -4.41 |
| 136 | 9285 | 2.77 | -4.44 |
| 137 | 9286 | 2.58 | -4.40 |
| 138 | 9287 | 2.60 | -4.36 |
| 139 | 8703 | 2.66 | -4.40 |
| 140 | 9288 | 2.68 | -4.24 |
| 141 | 9289 | 2.84 | -4.23 |
| 142 | 9290 | 2.85 | -4.20 |
| 143 | 9291 | 2.77 | -4.24 |
| 144 | 8704 | 2.79 | -4.27 |
| 145 | 9292 | 2.82 | -4.22 |
| 146 | 9293 | 2.82 | -4.23 |
| 147 | 9294 | 2.95 | -4.21 |
| 148 | 9295 | 2.87 | -4.18 |
| 149 | 8705 | 2.88 | -4.26 |
| 150 | 9296 | 2.92 | -4.23 |

| | | | |
|---|---|---|---|
| 151 | 9297 | 2.81 | -4.23 |
| 152 | 9298 | 2.80 | -4.19 |
| 153 | 9299 | 2.95 | -4.23 |
| 154 | 8706 | 2.92 | -4.40 |
| 155 | 9300 | 2.85 | -4.36 |
| 156 | 9301 | 2.93 | -4.41 |
| 157 | 9305 | 2.83 | -4.39 |
| 158 | 9306 | 2.78 | -4.42 |
| 159 | 9307 | 2.80 | -4.38 |
| 160 | 9308 | 2.79 | -4.50 |
| 161 | 9309 | 2.84 | -4.49 |
| 162 | 9310 | 2.84 | -4.51 |
| 163 | 9311 | 3.09 | -4.46 |
| 164 | 9312 | 2.84 | -4.67 |
| 166 | 9313 | 2.83 | -4.60 |
| 167 | 9314 | 2.89 | -4.44 |
| 168 | 9315 | 2.89 | -4.28 |
| 169 | 9316 | 3.03 | -4.11 |
| 170 | 9317 | 3.16 | -3.83 |
| 171 | 9318 | 3.20 | -3.77 |
| 173 | 9319 | 3.28 | -3.59 |
| 176 | 9320 | 3.42 | -3.71 |
| 177 | 9321 | 3.32 | -3.49 |
| 179 | 9322 | 3.48 | -3.38 |
| 180 | 9323 | 3.50 | -3.21 |
| 181 | 9324 | 3.86 | -3.19 |
| 182 | 9328 | 3.40 | -3.08 |
| 183 | 9329 | 3.67 | -2.92 |
| 184 | 9330 | 3.62 | -3.02 |
| 185 | 9331 | 3.53 | -2.98 |
| 186 | 9332 | 3.57 | -2.93 |
| 188 | 9333 | 3.42 | -2.79 |
| 189 | 9334 | 3.49 | -2.75 |
| 190 | 9335 | 3.64 | -2.69 |
| 191 | 9336 | 3.49 | -2.64 |
| 192 | 9337 | 3.56 | -2.49 |
| 193 | 9338 | 3.65 | -2.25 |
| 194 | 9339 | 3.41 | -2.29 |
| 195 | 9340 | 3.34 | -2.18 |
| 196 | 9341 | 3.51 | -1.94 |
| 197 | 9342 | 3.52 | -2.10 |
| 198 | 9343 | 3.41 | -2.31 |
| 199 | 9344 | 3.54 | -2.43 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 200 | 9345 | 3.17 | -3.49 |
| | | | 201 | 9346 | 3.05 | -4.29 |
| | | | 202 | 9347 | 3.54 | -2.58 |
| | | | 203 | 9351 | 3.07 | -2.65 |
| | | | 204 | 9352 | 3.11 | -1.74 |
| | | | 205 | 9353 | 3.02 | -1.84 |
| | | | 206 | 9354 | 3.00 | -1.40 |
| | | | 207 | 9355 | 2.72 | -0.86 |
| | | | 208 | 9356 | 2.55 | -1.15 |
| | | | 209 | 9357 | 2.34 | -1.42 |
| | | | 210 | 9358 | 2.56 | -1.02 |
| | | | 211 | 9359 | 3.05 | -1.74 |
| | | | 212 | 9360 | 3.14 | -2.65 |
| | | | 213 | 9361 | 3.02 | -2.36 |
| | | | 214 | 9362 | 2.78 | -1.64 |
| MD99-2266 | 150-151.5 | *Thyasira flexuosa* | 0 | 3544 | 3.03 | -5.74 |
| | | | 2 | 3545 | 2.60 | -5.17 |
| | | | 3 | 3546 | 2.37 | -4.98 |
| | | | 6 | 4265 | 2.17 | -5.73 |
| | | | 7 | 3995 | 2.25 | -5.73 |
| | | | 8 | 3996 | 2.51 | -5.40 |
| | | | 11 | 3997 | 2.61 | -5.19 |
| | | | 16 | 3999 | 2.82 | -5.32 |
| | | | 18 | 4000 | 2.91 | -5.17 |
| | | | 20 | 3548 | 2.89 | -5.13 |
| | | | 22 | 4001 | 2.89 | -5.10 |
| | | | 23 | 4067 | 2.76 | -5.18 |
| | | | 24 | 4068 | 2.78 | -5.21 |
| | | | 30 | 3549 | 2.68 | -5.51 |
| | | | 39 | 3550 | 2.23 | -6.29 |
| | | | 44 | 4266 | 2.30 | -5.53 |
| | | | 45 | 4069 | 2.14 | -5.73 |
| | | | 46 | 4267 | 2.22 | -5.05 |
| | | | 49 | 4082 | 2.23 | -5.03 |
| | | | 50 | 4002 | 2.34 | -4.87 |
| | | | 51 | 4083 | 2.28 | -4.66 |
| | | | 59 | 4268 | 2.40 | -4.48 |
| | | | 60 | 4003 | 2.54 | -4.42 |
| | | | 61 | 4269 | 2.38 | -4.51 |
| | | | 70 | 4004 | 2.93 | -4.48 |
| | | | 80 | 4005 | 3.05 | -3.84 |
| | | | 89 | 4070 | 3.12 | -3.62 |

| | | | |
|---|---|---|---|
| 90 | 4006 | 3.29 | -3.57 |
| 91 | 4071 | 3.13 | -3.60 |
| 99 | 4332 | 3.29 | -3.63 |
| 100 | 4007 | 3.15 | -3.73 |
| 101 | 4333 | 3.20 | -3.71 |
| 110 | 4008 | 3.10 | -3.85 |
| 120 | 4009 | 2.56 | -4.26 |
| 130 | 4010 | 2.57 | -4.64 |
| 139 | 4072 | 2.46 | -4.35 |
| 140 | 4011 | 2.40 | -4.32 |
| 141 | 4073 | 2.38 | -4.34 |
| 145 | 4270 | 2.60 | -4.16 |
| 150 | 4012 | 2.45 | -4.17 |
| 160 | 4013 | 2.44 | -4.07 |
| 170 | 4014 | 2.54 | -4.24 |
| 180 | 4018 | 2.89 | -3.97 |
| 190 | 4019 | 2.87 | -3.92 |
| 200 | 4020 | 3.18 | -4.12 |
| 210 | 4021 | 3.38 | -4.81 |
| 220 | 4022 | 3.30 | -5.28 |
| 229 | 4074 | 3.38 | -5.37 |
| 230 | 4023 | 3.37 | -5.41 |
| 231 | 4075 | 3.40 | -5.32 |
| 240 | 4024 | 3.31 | -4.92 |
| 250 | 4025 | 3.36 | -5.09 |
| 260 | 4026 | 2.95 | -5.16 |
| 269 | 4076 | 2.99 | -4.85 |
| 271 | 4077 | 2.84 | -4.74 |
| 280 | 4028 | 2.77 | -5.01 |
| 290 | 4029 | 2.73 | -4.61 |
| 300 | 4030 | 2.85 | -4.64 |
| 310 | 4031 | 2.61 | -4.64 |
| 320 | 4032 | 2.56 | -4.17 |
| 329 | 4078 | 2.42 | -3.76 |
| 331 | 4271 | 2.47 | -3.72 |
| 338 | 4334 | 2.69 | -4.52 |
| 339 | 4079 | 2.36 | -4.60 |
| 341 | 4272 | 2.68 | -4.75 |
| 349 | 4080 | 2.70 | -5.09 |
| 359 | 4081 | 2.54 | -4.93 |
| 380 | 4041 | 2.64 | -5.07 |
| 390 | 4042 | 2.61 | -4.12 |
| 400 | 4043 | 2.82 | -4.01 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 410 | 4044 | 3.28 | -3.53 |
| | | | 419 | 4273 | 3.79 | -2.38 |
| | | | 420 | 4045 | 3.64 | -2.02 |
| | | | 421 | 4274 | 3.62 | -2.12 |
| | | | 422 | 4064 | 3.35 | -2.19 |
| | | | 423 | 4065 | 3.19 | -1.61 |
| | | | 424 | 4066 | 3.36 | -2.68 |
| MD99-2266 | 157-159 | *Thyasira flexuosa* | 0 | 5246 | 2.28 | -3.80 |
| | | | 1 | 5247 | 2.23 | -3.85 |
| | | | 2 | 5468 | 2.35 | -3.84 |
| | | | 3 | 5610 | 2.28 | -3.58 |
| | | | 4 | 5469 | 2.42 | -3.39 |
| | | | 5 | 5248 | 2.42 | -3.31 |
| | | | 10 | 5249 | 2.37 | -3.92 |
| | | | 20 | 5250 | 2.38 | -3.84 |
| | | | 29 | 5556 | 2.21 | -3.97 |
| | | | 30 | 5470 | 2.17 | -4.00 |
| | | | 31 | 5557 | 2.19 | -4.03 |
| | | | 40 | 5251 | 2.38 | -3.89 |
| | | | 58 | 5558 | 2.93 | -3.26 |
| | | | 59 | 5559 | 3.04 | -3.26 |
| | | | 60 | 5252 | 3.00 | -3.27 |
| | | | 70 | 5471 | 2.94 | -3.63 |
| | | | 80 | 5253 | 2.90 | -3.11 |
| | | | 100 | 5254 | 2.49 | -3.14 |
| | | | 120 | 5255 | 2.23 | -3.17 |
| | | | 129 | 5560 | 2.19 | -2.46 |
| | | | 130 | 5472 | 2.14 | -2.45 |
| | | | 131 | 5561 | 2.08 | -2.43 |
| | | | 132 | 5611 | 2.12 | -2.43 |
| | | | 140 | 5256 | 2.23 | -2.65 |
| | | | 160 | 5257 | 2.56 | -2.46 |
| | | | 178 | 5612 | 3.16 | -1.61 |
| | | | 179 | 5562 | 3.09 | -1.60 |
| | | | 180 | 5473 | 2.98 | -1.59 |
| | | | 181 | 5563 | 3.08 | -1.62 |
| | | | 182 | 5613 | 3.12 | -1.56 |
| | | | 199 | 5564 | 2.26 | -2.34 |
| | | | 200 | 5474 | 2.17 | -2.38 |
| | | | 201 | 5565 | 2.23 | -2.30 |
| | | | 220 | 5475 | 2.39 | -1.97 |
| | | | 241 | 5476 | 2.56 | -1.99 |

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|---|---|---|---|---|---|---|
| | | | 261 | 5477 | 2.77 | -1.90 |
| | | | 279 | 5566 | 3.29 | -1.64 |
| | | | 280 | 5478 | 3.32 | -1.62 |
| | | | 281 | 5567 | 3.37 | -1.54 |
| | | | 282 | 5614 | 3.36 | -1.49 |
| | | | 299 | 5568 | 2.57 | -1.48 |
| | | | 300 | 5479 | 2.28 | -1.48 |
| | | | 301 | 5569 | 2.08 | -1.39 |
| | | | 302 | 5615 | 2.07 | -1.19 |
| | | | 303 | 5616 | 2.04 | -1.17 |
| | | | 320 | 5480 | 3.06 | -1.62 |
| | | | 323 | 611 | 3.24 | -1.89 |
| | | | 325 | 5570 | 3.25 | -1.59 |
| | | | 326 | 5617 | 3.03 | -1.87 |
| | | | 327 | 1008 | 2.67 | -2.14 |
| | | | 328 | 5618 | 2.46 | -1.83 |
| | | | 330 | 1009 | 2.17 | -1.21 |
| | | | 331 | 1072 | 2.17 | -0.92 |
| | | | 332 | 1010 | 2.14 | -0.77 |
| | | | 333 | 1073 | 2.20 | -0.92 |
| | | | 338 | 1011 | 2.52 | -1.30 |
| | | | 340 | 5481 | 2.65 | -1.34 |
| | | | 342 | 1012 | 2.62 | -1.89 |
| | | | 344 | 1013 | 2.69 | -2.64 |
| | | | 345 | 1077 | 2.81 | -1.95 |
| | | | 349 | 5571 | 2.21 | -1.36 |
| | | | 350 | 5482 | 2.13 | -0.99 |
| | | | 351 | 5572 | 2.13 | -0.72 |
| | | | 352 | 5619 | 2.16 | -0.60 |
| | | | 358 | 5483 | 2.43 | -0.81 |
| MD99-2266 | 174.5-175.5 | *Macoma calcarea* | 4 | 9535 | 2.23 | 0.66 |
| | | | 6 | 1030 | 2.98 | 0.82 |
| | | | 7 | 1031 | 2.99 | 0.86 |
| | | | 8 | 15008 | 3.09 | 0.89 |
| | | | 9 | 9536 | 2.56 | 0.61 |
| | | | 10 | 15009 | 3.15 | 0.69 |
| | | | 11 | 1032 | 3.10 | 0.66 |
| | | | 12 | 15010 | 2.74 | 0.77 |
| | | | 14 | 9537 | 2.84 | 0.69 |
| | | | 15 | 13779 | 3.48 | 0.51 |
| | | | 16 | 15011 | 3.44 | 0.69 |
| | | | 17 | 1033 | 3.38 | 0.62 |

| | | | |
|---|---|---|---|
| 18 | 15012 | 3.53 | 0.61 |
| 20 | 15013 | 3.66 | 0.88 |
| 21 | 1313 | 3.62 | 0.84 |
| 22 | 15014 | 3.73 | 1.00 |
| 23 | 13780 | 3.92 | 1.05 |
| 24 | 9539 | 2.41 | 0.32 |
| 26 | 15015 | 2.88 | 0.48 |
| 27 | 15016 | 2.43 | 0.50 |
| 28 | 15017 | 2.28 | 0.56 |
| 29 | 9540 | 2.66 | 0.06 |
| 30 | 1314 | 2.44 | 0.92 |
| 33 | 1317 | 2.77 | 0.92 |
| 34 | 9541 | 2.87 | 0.11 |
| 35 | 15018 | 2.49 | 0.95 |
| 36 | 15019 | 2.72 | 0.95 |
| 37 | 13782 | 2.46 | 0.92 |
| 38 | 13783 | 2.69 | 1.03 |
| 39 | 9542 | 3.07 | 0.57 |
| 40 | 13784 | 2.65 | 0.89 |
| 42 | 1318 | 2.57 | 0.84 |
| 43 | 13785 | 2.71 | 0.73 |
| 43 | 1319 | 2.36 | 0.81 |
| 44 | 9543 | 2.32 | 0.44 |
| 45 | 13786 | 2.73 | 0.67 |
| 46 | 13787 | 2.80 | 0.67 |
| 47 | 1034 | 2.45 | 0.63 |
| 49 | 9544 | 2.46 | 0.54 |
| 54 | 9545 | 2.56 | 0.18 |
| 59 | 9546 | 2.65 | 0.04 |
| 64 | 9547 | 2.68 | 0.19 |
| 69 | 9548 | 2.77 | 0.28 |
| 74 | 9549 | 2.77 | 0.29 |
| 77 | 1320 | 2.64 | -0.02 |
| 78 | 1321 | 2.72 | 0.04 |
| 80 | 1036 | 2.98 | 0.19 |
| 81 | 1037 | 2.61 | 0.11 |
| 82 | 1038 | 2.68 | 0.39 |
| 83 | 15041 | 2.62 | 0.51 |
| 85 | 15020 | 2.63 | 0.63 |
| 86 | 15021 | 2.73 | 0.70 |
| 87 | 13788 | 2.83 | 0.69 |
| 88 | 13789 | 2.95 | 0.54 |
| 90 | 13790 | 2.99 | 0.38 |

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|---|---|---|---|
| 91 | 15022 | 3.03 | 0.47 |
| 92 | 1043 | 3.12 | 0.46 |
| 93 | 1322 | 2.93 | 0.63 |
| 95 | 1323 | 3.03 | 0.68 |
| 96 | 1324 | 3.31 | 0.66 |
| 97 | 1325 | 3.40 | 0.77 |
| 98 | 1326 | 3.39 | 0.59 |
| 100 | 1327 | 2.62 | 0.34 |
| 101 | 1328 | 2.38 | 0.34 |
| 102 | 15023 | 2.41 | 0.53 |
| 103 | 13791 | 2.65 | 0.78 |
| 104 | 9558 | 2.88 | 0.78 |
| 105 | 13792 | 2.71 | 0.81 |
| 106 | 13797 | 2.35 | 0.58 |
| 107 | 15024 | 2.50 | 0.68 |
| 108 | 15025 | 2.63 | 0.68 |
| 109 | 9559 | 3.02 | 0.63 |
| 110 | 15026 | 2.86 | 0.65 |
| 111 | 15031 | 2.82 | 0.63 |
| 113 | 1044 | 3.02 | 0.57 |
| 114 | 9560 | 3.37 | 0.51 |
| 115 | 1045 | 3.17 | 0.85 |
| 116 | 1329 | 3.01 | 0.81 |
| 117 | 1330 | 3.12 | 0.86 |
| 118 | 1046 | 3.28 | 0.57 |
| 119 | 9561 | 3.40 | 0.76 |
| 120 | 1047 | 2.83 | 0.42 |
| 121 | 1048 | 2.65 | 0.56 |
| 122 | 13798 | 2.46 | 0.45 |
| 123 | 13799 | 2.34 | 0.16 |
| 125 | 13800 | 2.60 | 0.36 |
| 126 | 13801 | 2.70 | 0.41 |
| 127 | 13802 | 2.71 | 0.34 |
| 128 | 13803 | 2.70 | 0.16 |
| 130 | 13804 | 2.87 | 0.26 |
| 131 | 13805 | 3.00 | 0.49 |
| 132 | 1049 | 3.06 | 0.40 |
| 133 | 15032 | 2.93 | 0.30 |
| 135 | 15033 | 3.08 | 0.18 |
| 136 | 1050 | 3.17 | 0.36 |
| 137 | 1051 | 3.20 | 0.51 |
| 138 | 1331 | 3.23 | 0.61 |
| 139 | 9565 | 2.43 | 0.86 |

| | | | |
|---|---|---|---|
| 144 | 9566 | 2.45 | 0.62 |
| 147 | 15034 | 2.49 | 0.63 |
| 148 | 13806 | 2.50 | 0.68 |
| 149 | 9567 | 2.63 | 0.72 |
| 150 | 13807 | 2.55 | 0.50 |
| 154 | 9568 | 2.57 | 0.45 |
| 159 | 9569 | 2.65 | 0.11 |
| 164 | 9570 | 2.76 | -0.10 |
| 169 | 9571 | 2.76 | 0.36 |
| 170 | 15035 | 2.82 | 0.33 |
| 172 | 15036 | 2.99 | 0.28 |
| 173 | 13808 | 2.94 | 0.36 |
| 174 | 9572 | 2.60 | -0.05 |
| 175 | 13809 | 2.96 | 0.42 |
| 176 | 2351 | 2.91 | 0.37 |
| 177 | 2801 | 2.84 | 0.33 |
| 178 | 2352 | 3.20 | 0.31 |
| 179 | 9573 | 2.83 | 0.31 |
| 180 | 2353 | 3.31 | 0.30 |
| 181 | 2354 | 3.37 | 0.21 |
| 182 | 13810 | 3.54 | 0.24 |
| 183 | 13811 | 3.58 | 0.24 |
| 186 | 15037 | 3.67 | 0.68 |
| 193 | 2356 | 3.49 | 0.38 |
| 194 | 2357 | 3.28 | 0.50 |
| 195 | 10000 | 3.04 | 0.42 |
| 200 | 10001 | 3.01 | 0.66 |
| 205 | 10002 | 2.91 | 0.53 |
| 207 | 15039 | 2.88 | 0.45 |
| 209 | 13812 | 3.29 | 0.52 |
| 209 | 1055 | 2.94 | 0.54 |
| 210 | 10003 | 2.66 | 0.52 |
| 211 | 13813 | 3.02 | 0.45 |
| 212 | 1056 | 3.00 | 0.19 |
| 215 | 1173 | 2.81 | 0.17 |
| 217 | 10004 | 2.71 | 0.45 |
| 223 | 13814 | 2.86 | 0.17 |
| 225 | 13815 | 3.02 | 0.05 |
| 227 | 10005 | 2.53 | 0.03 |
| 231 | 13871 | 2.85 | -0.64 |
| 234 | 13870 | 3.27 | -0.18 |
| 236 | 10006 | 3.01 | 0.02 |

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|---|---|---|---|---|---|---|
| MD99-2266 | 208-209 | *Tellina tenuis* | 2 | 13914 | 2.50 | 0.29 |
| | | | 4 | 13916 | 2.38 | 0.86 |
| | | | 5 | 13917 | 2.45 | 0.14 |
| | | | 6 | 9363 | 2.18 | -0.50 |
| | | | 7 | 1243 | 2.11 | -0.75 |
| | | | 8 | 1244 | 2.18 | -0.59 |
| | | | 9 | 1245 | 2.31 | -0.24 |
| | | | 10 | 10039 | 2.30 | 0.02 |
| | | | 12 | 10040 | 2.49 | 0.48 |
| | | | 13 | 13918 | 2.63 | 0.43 |
| | | | 14 | 13919 | 2.47 | 0.03 |
| | | | 19 | 9366 | 2.63 | 1.18 |
| | | | 25 | 10041 | 2.94 | 1.22 |
| | | | 26 | 9367 | 2.95 | 0.44 |
| | | | 27 | 10042 | 3.04 | 1.13 |
| | | | 28 | 10043 | 2.86 | 1.08 |
| | | | 29 | 2736 | 3.21 | 1.06 |
| | | | 30 | 2737 | 3.20 | 1.00 |
| | | | 31 | 9368 | 2.91 | 0.79 |
| | | | 34 | 1246 | 2.19 | -0.17 |
| | | | 36 | 10044 | 2.06 | 0.53 |
| | | | 39 | 1247 | 2.33 | 1.04 |
| | | | 40 | 1248 | 2.33 | 1.15 |
| | | | 41 | 9370 | 2.50 | 1.34 |
| | | | 46 | 9374 | 2.59 | 1.11 |
| | | | 47 | 2738 | 3.05 | 1.31 |
| | | | 48 | 2742 | 2.75 | 1.13 |
| | | | 49 | 2743 | 2.75 | 1.00 |
| | | | 51 | 9375 | 2.39 | 0.79 |
| | | | 54 | 2744 | 2.86 | 0.74 |
| | | | 55 | 2745 | 2.95 | 0.71 |
| | | | 56 | 9376 | 2.52 | 0.68 |
| | | | 57 | 1249 | 2.61 | 0.75 |
| | | | 58 | 1250 | 2.65 | 0.97 |
| | | | 61 | 9377 | 2.81 | 1.19 |
| | | | 63 | 1251 | 2.83 | 1.04 |
| | | | 64 | 1252 | 2.78 | 0.90 |
| | | | 66 | 9378 | 2.14 | 0.96 |
| | | | 69 | 2746 | 2.92 | 1.63 |
| | | | 70 | 2747 | 2.73 | 1.64 |
| | | | 76 | 9379 | 2.53 | 1.54 |
| | | | 81 | 9380 | 2.76 | 1.36 |
| | | | 86 | 9381 | 2.83 | 1.22 |

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|---|---|---|---|
| 91 | 9382 | 3.00 | 1.21 |
| 96 | 9383 | 3.07 | 1.26 |
| 101 | 9384 | 3.10 | 1.21 |
| 106 | 9385 | 3.11 | 1.19 |
| 109 | 10036 | 3.20 | 1.17 |
| 110 | 10037 | 3.46 | 1.17 |
| 111 | 9386 | 3.61 | 1.26 |
| 112 | 10038 | 3.29 | 1.13 |
| 116 | 9387 | 3.33 | 1.31 |
| 121 | 9388 | 3.28 | 0.95 |
| 123 | 1253 | 3.39 | 1.04 |
| 125 | 1254 | 3.43 | 0.73 |
| 127 | 1255 | 2.44 | 0.70 |
| 129 | 1377 | 2.30 | 0.71 |
| 131 | 9389 | 2.26 | 0.51 |
| 136 | 9390 | 2.26 | 0.64 |
| 137 | 1257 | 2.45 | 0.43 |
| 139 | 1258 | 2.62 | 0.56 |
| 141 | 9391 | 2.61 | 0.79 |
| 146 | 9392 | 2.66 | 0.85 |
| 148 | 1378 | 2.85 | 0.94 |
| 151 | 9393 | 2.51 | 0.86 |
| 152 | 1379 | 2.89 | 0.79 |
| 154 | 1380 | 2.88 | 0.80 |
| 156 | 10028 | 2.91 | 0.71 |
| 161 | 10029 | 3.03 | 0.76 |
| 168 | 10030 | 3.16 | 0.71 |
| 172 | 1284 | 3.08 | 0.35 |
| 173 | 1268 | 3.02 | 0.35 |
| 174 | 1266 | 3.10 | -0.01 |
| 175 | 10031 | 3.25 | -0.10 |
| 177 | 1267 | 3.30 | 0.02 |
| 178 | 1269 | 3.43 | 0.21 |
| 180 | 10032 | 3.35 | 0.14 |
| 182 | 1270 | 3.24 | 0.39 |
| 183 | 1271 | 3.08 | 0.50 |
| 184 | 1272 | 2.99 | 0.61 |
| 185 | 1273 | 2.96 | 0.65 |
| 186 | 10033 | 2.73 | 0.54 |
| 189 | 14108 | 2.90 | 0.43 |
| 191 | 1275 | 2.72 | 0.64 |
| 192 | 1276 | 2.86 | 0.62 |
| 194 | 10034 | 2.96 | 0.54 |

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|---|---|---|---|---|---|---|
| | | | 196 | 1277 | 2.99 | 0.57 |
| | | | 198 | 1278 | 2.98 | 0.62 |
| | | | 200 | 1279 | 3.04 | 0.54 |
| | | | 202 | 1280 | 3.04 | 0.28 |
| | | | 210 | 1282 | 3.19 | -0.05 |
| MD99-2266 | 222 | *Thyasira flexuosa* | 0 | 4309 | 1.77 | -5.66 |
| | | | 1 | 4310 | 1.93 | -5.27 |
| | | | 5 | 4311 | 1.95 | -5.07 |
| | | | 9 | 1014 | 2.23 | -4.44 |
| | | | 9.5 | 4312 | 2.48 | -4.17 |
| | | | 10 | 1015 | 2.28 | -4.19 |
| | | | 14 | 1016 | 2.18 | -4.57 |
| | | | 15 | 5039 | 2.11 | -4.73 |
| | | | 16 | 1017 | 2.12 | -4.82 |
| | | | 20 | 4313 | 2.41 | -4.88 |
| | | | 25 | 5040 | 2.69 | -4.68 |
| | | | 27 | 1018 | 2.58 | -4.47 |
| | | | 29 | 614 | 2.71 | -4.14 |
| | | | 30 | 4314 | 2.91 | -4.13 |
| | | | 31 | 1078 | 2.54 | -4.21 |
| | | | 32 | 1079 | 2.47 | -4.28 |
| | | | 34 | 618 | 2.31 | -4.45 |
| | | | 35 | 5041 | 1.96 | -4.80 |
| | | | 36 | 619 | 2.01 | -4.83 |
| | | | 40 | 4315 | 2.50 | -4.96 |
| | | | 50 | 4316 | 3.22 | -3.70 |
| | | | 54 | 620 | 3.19 | -3.48 |
| | | | 56 | 621 | 3.15 | -3.43 |
| | | | 60 | 4317 | 3.23 | -3.11 |
| | | | 62 | 1019 | 2.94 | -3.08 |
| | | | 70 | 4318 | 2.77 | -3.32 |
| | | | 78 | 1021 | 2.28 | -3.99 |
| | | | 79 | 622 | 1.82 | -5.01 |
| | | | 80 | 4319 | 1.98 | -5.00 |
| | | | 82 | 4327 | 2.02 | -4.87 |
| | | | 84 | 4328 | 2.14 | -4.59 |
| | | | 90 | 4320 | 2.57 | -3.96 |
| | | | 100 | 4321 | 2.63 | -2.74 |
| | | | 106 | 623 | 3.15 | -0.58 |
| | | | 108 | 624 | 3.33 | -0.31 |
| | | | 110 | 4322 | 3.53 | -0.31 |
| | | | 112 | 1022 | 3.45 | -0.26 |

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|---|---|---|---|---|---|---|
| | | | 114 | 1023 | 3.35 | -0.28 |
| | | | 120 | 4323 | 3.08 | -0.39 |
| | | | 130 | 4324 | 2.75 | -0.31 |
| | | | 138 | 625 | 2.35 | -0.51 |
| | | | 140 | 4325 | 2.41 | -0.58 |
| | | | 142 | 626 | 2.31 | -0.55 |
| | | | 144 | 1080 | 2.27 | -0.60 |
| | | | 146 | 1081 | 2.42 | -0.46 |
| | | | 150 | 4326 | 2.52 | -0.56 |
| | | | 158 | 1082 | 2.39 | -0.63 |
| | | | 159 | 1083 | 2.45 | -0.62 |
| | | | 160 | 4993 | 2.47 | -0.64 |
| | | | 170 | 4994 | 2.79 | -0.88 |
| | | | 180 | 4995 | 3.42 | -0.65 |
| | | | 182 | 628 | 3.49 | -0.57 |
| | | | 184 | 1025 | 3.37 | -0.70 |
| | | | 190 | 4996 | 2.84 | -0.93 |
| | | | 200 | 4997 | 2.67 | -2.11 |
| | | | 210 | 4998 | 2.61 | -0.70 |
| | | | 219 | 629 | 2.11 | -0.70 |
| | | | 220 | 4999 | 2.07 | -0.74 |
| | | | 222 | 1026 | 2.13 | -0.61 |
| | | | 223 | 1027 | 2.17 | -0.68 |
| | | | 229 | 1031 | 2.63 | -0.03 |
| | | | 230 | 5000 | 2.61 | -0.11 |
| | | | 236 | 631 | 2.89 | -0.74 |
| | | | 237 | 1033 | 2.87 | -1.57 |
| | | | 238 | 632 | 3.29 | -2.27 |
| | | | 240 | 5001 | 2.72 | -1.82 |
| | | | 241 | 1084 | 2.60 | -1.46 |
| | | | 250 | 5002 | 2.37 | -1.06 |
| MD99-2266 | 241.5-243 | *Thyasira flexuosa* | 0 | 5003 | 2.89 | -2.30 |
| | | | 1 | 5004 | 3.03 | -2.16 |
| | | | 2 | 5269 | 2.87 | -2.27 |
| | | | 4 | 5270 | 2.78 | -2.33 |
| | | | 5 | 5005 | 2.71 | -2.26 |
| | | | 10 | 5006 | 2.33 | -2.50 |
| | | | 13 | 5271 | 2.21 | -2.79 |
| | | | 14 | 5814 | 2.11 | -2.92 |
| | | | 15 | 5815 | 1.94 | -2.91 |
| | | | 16 | 633 | 2.21 | -3.01 |
| | | | 20 | 5007 | 2.29 | -3.13 |

| | | | |
|---|---|---|---|
| 30 | 5008 | 2.71 | -2.35 |
| 40 | 5009 | 3.12 | -1.76 |
| 44 | 5816 | 3.35 | -1.65 |
| 45 | 5272 | 3.30 | -1.53 |
| 46 | 5818 | 2.91 | -1.55 |
| 50 | 5010 | 3.00 | -0.99 |
| 60 | 5011 | 2.65 | -0.94 |
| 70 | 5012 | 2.50 | -1.32 |
| 72 | 5273 | 2.49 | -1.29 |
| 75 | 5274 | 2.53 | -1.09 |
| 79 | 634 | 2.51 | -0.93 |
| 80 | 5016 | 2.61 | -0.90 |
| 81 | 635 | 2.56 | -0.90 |
| 85 | 5275 | 2.52 | -1.00 |
| 90 | 5017 | 2.56 | -1.08 |
| 98 | 5819 | 3.08 | -1.22 |
| 99 | 5278 | 3.14 | -1.10 |
| 100 | 5018 | 2.99 | -1.13 |
| 101 | 5279 | 2.81 | -1.24 |
| 107 | 5276 | 2.44 | -1.55 |
| 109 | 5277 | 2.41 | -1.95 |
| 110 | 5019 | 2.65 | -1.65 |
| 115 | 5280 | 3.13 | -0.99 |
| 116 | 5820 | 3.09 | -0.86 |
| 119 | 5281 | 3.00 | -0.52 |
| 120 | 5020 | 2.87 | -0.50 |
| 121 | 5282 | 2.81 | -0.51 |
| 129 | 5283 | 2.52 | -0.67 |
| 130 | 5021 | 2.59 | -0.59 |
| 131 | 5284 | 2.51 | -0.64 |
| 140 | 5022 | 2.82 | -0.77 |
| 144 | 5821 | 2.87 | -0.89 |
| 145 | 5285 | 2.97 | -0.87 |
| 146 | 5822 | 2.78 | -0.83 |
| 150 | 5023 | 2.75 | -0.57 |
| 158 | 5286 | 2.56 | -0.56 |
| 160 | 5024 | 2.53 | -0.64 |
| 165 | 5823 | 2.43 | -0.71 |
| 170 | 5025 | 2.59 | -0.53 |
| 180 | 5026 | 2.91 | -0.47 |
| 186 | 636 | 3.21 | -0.64 |
| 189 | 1035 | 3.28 | -0.45 |
| 190 | 5027 | 3.28 | -0.49 |

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|---|---|---|---|---|---|---|
| | | | 192 | 5824 | 3.07 | -0.39 |
| | | | 199 | 5288 | 2.65 | -0.14 |
| | | | 200 | 5028 | 2.56 | -0.11 |
| | | | 203 | 1036 | 2.55 | -0.36 |
| | | | 204 | 1037 | 2.42 | -0.37 |
| | | | 205 | 5825 | 2.42 | -0.48 |
| | | | 209 | 5029 | 2.60 | -1.66 |
| | | | 219 | 5826 | 2.74 | -1.03 |
| | | | 220 | 5030 | 2.97 | -0.46 |
| | | | 221 | 5827 | 3.06 | -0.37 |
| | | | 222 | 1038 | 3.12 | -0.71 |
| | | | 223 | 1039 | 3.31 | -0.38 |
| | | | 229 | 5828 | 2.54 | -1.90 |
| | | | 230 | 5031 | 2.52 | -1.88 |
| | | | 231 | 1040 | 2.88 | -1.87 |
| | | | 236 | 5038 | 2.75 | -1.65 |
| MD99-2266 | 244-245.5 | *Thyasira flexuosa* | 0 | 5514 | 1.88 | -3.46 |
| | | | 1 | 5515 | 1.57 | -3.64 |
| | | | 2 | 5573 | 1.43 | -4.00 |
| | | | 3 | 5574 | 1.49 | -4.08 |
| | | | 5 | 5516 | 1.76 | -3.79 |
| | | | 9 | 5671 | 2.26 | -2.90 |
| | | | 10 | 5517 | 2.45 | -2.35 |
| | | | 11 | 5672 | 2.54 | -2.08 |
| | | | 14 | 5579 | 2.80 | -1.45 |
| | | | 19 | 5811 | 2.97 | -1.36 |
| | | | 20 | 5518 | 2.85 | -1.41 |
| | | | 21 | 5812 | 2.95 | -1.41 |
| | | | 38 | 5580 | 1.10 | -4.66 |
| | | | 40 | 5519 | 1.06 | -4.83 |
| | | | 42 | 5581 | 1.17 | -5.05 |
| | | | 60 | 5520 | 2.34 | -2.44 |
| | | | 80 | 5521 | 2.92 | -2.97 |
| | | | 85 | 5582 | 3.20 | -2.77 |
| | | | 87 | 5673 | 3.23 | -2.69 |
| | | | 88 | 5674 | 3.17 | -2.73 |
| | | | 90 | 5583 | 3.20 | -2.75 |
| | | | 100 | 5522 | 2.83 | -2.71 |
| | | | 119 | 5675 | 2.21 | -2.66 |
| | | | 120 | 5523 | 2.10 | -2.76 |
| | | | 125 | 5584 | 2.16 | -2.71 |
| | | | 130 | 5585 | 2.12 | -2.61 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 140 | 5524 | 2.15 | -2.28 |
| | | | 160 | 5525 | 2.33 | -1.53 |
| | | | 180 | 5526 | 2.59 | -1.43 |
| | | | 200 | 5527 | 2.94 | -0.57 |
| | | | 205 | 5586 | 2.98 | -0.54 |
| | | | 210 | 5587 | 3.12 | -0.33 |
| | | | 212 | 5676 | 3.13 | -0.33 |
| | | | 220 | 5528 | 2.78 | -0.24 |
| | | | 238 | 5588 | 2.41 | -0.31 |
| | | | 240 | 5529 | 2.22 | -0.45 |
| | | | 242 | 5589 | 2.34 | -0.40 |
| | | | 258 | 5590 | 2.90 | -0.41 |
| | | | 260 | 5530 | 3.01 | -0.47 |
| | | | 262 | 5591 | 3.19 | -0.13 |
| | | | 264 | 5677 | 3.30 | -0.17 |
| | | | 266 | 5678 | 3.37 | -0.01 |
| | | | 267 | 5813 | 3.07 | 0.14 |
| | | | 283 | 5592 | 2.56 | -1.76 |
| | | | 285 | 5532 | 2.36 | -0.76 |
| | | | 287 | 5533 | 2.46 | -2.70 |
| MD99-2266 | 258.5-259.5 | *Thyasira flexuosa* | 1 | 13821 | 1.52 | -3.93 |
| | | | 2 | 13822 | 1.48 | -3.66 |
| | | | 3 | 13823 | 2.20 | -2.11 |
| | | | 4 | 9445 | 2.14 | -1.84 |
| | | | 5 | 15057 | 2.62 | -1.18 |
| | | | 6 | 15058 | 2.56 | -1.25 |
| | | | 7 | 15059 | 2.37 | -1.36 |
| | | | 8 | 13824 | 1.51 | -3.30 |
| | | | 9 | 9446 | 1.52 | -2.81 |
| | | | 10 | 13825 | 2.09 | -2.71 |
| | | | 12 | 15061 | 2.78 | -1.78 |
| | | | 13 | 15062 | 2.72 | -1.71 |
| | | | 15 | 15063 | 2.14 | -1.48 |
| | | | 16 | 15064 | 1.98 | -1.63 |
| | | | 17 | 13826 | 1.56 | -1.95 |
| | | | 18 | 13827 | 1.60 | -2.06 |
| | | | 19 | 9448 | 1.86 | -2.00 |
| | | | 20 | 13828 | 2.02 | -1.84 |
| | | | 21 | 13829 | 2.04 | -1.92 |
| | | | 22 | 13830 | 2.16 | -1.89 |
| | | | 23 | 13831 | 2.13 | -2.04 |
| | | | 24 | 9449 | 2.09 | -2.14 |

| | | | |
|---|---|---|---|
| 25 | 13832 | 2.03 | -2.14 |
| 26 | 13833 | 1.98 | -2.12 |
| 27 | 15065 | 2.03 | -2.46 |
| 28 | 13834 | 1.48 | -3.31 |
| 29 | 9450 | 1.66 | -3.16 |
| 31 | 1300 | 1.48 | -3.39 |
| 32 | 1301 | 1.42 | -3.42 |
| 33 | 1302 | 1.50 | -3.53 |
| 34 | 9451 | 1.64 | -3.64 |
| 35 | 15066 | 2.13 | -2.92 |
| 36 | 15067 | 2.28 | -2.29 |
| 37 | 13835 | 1.82 | -2.55 |
| 38 | 13836 | 1.54 | -3.01 |
| 39 | 9452 | 1.49 | -3.49 |
| 40 | 13837 | 1.73 | -3.72 |
| 41 | 13838 | 1.75 | -3.38 |
| 45 | 9453 | 1.99 | -2.66 |
| 46 | 1303 | 2.37 | -1.80 |
| 47 | 15068 | 2.77 | -1.28 |
| 48 | 15069 | 2.92 | -0.93 |
| 49 | 13843 | 2.55 | -0.68 |
| 50 | 9454 | 2.50 | -0.59 |
| 51 | 13844 | 2.35 | -0.58 |
| 55 | 9455 | 2.05 | -0.75 |
| 58 | 13861 | 1.87 | -1.02 |
| 59 | 13845 | 1.72 | -1.01 |
| 60 | 9456 | 1.88 | -1.07 |
| 61 | 13846 | 1.80 | -1.14 |
| 62 | 13847 | 1.69 | -1.17 |
| 63 | 15070 | 2.26 | -1.16 |
| 65 | 9457 | 1.99 | -1.73 |
| 68 | 13848 | 2.37 | -2.11 |
| 69 | 13849 | 2.29 | -2.31 |
| 70 | 9458 | 2.50 | -2.33 |
| 71 | 13850 | 2.46 | -2.10 |
| 72 | 13851 | 2.58 | -1.82 |
| 73 | 15071 | 2.88 | -1.59 |
| 74 | 15072 | 2.69 | -1.49 |
| 75 | 9459 | 2.31 | -1.62 |
| 78 | 13852 | 2.07 | -1.54 |
| 79 | 13853 | 2.03 | -1.62 |
| 80 | 9460 | 1.88 | -1.66 |
| 81 | 13854 | 1.94 | -1.62 |

| | | | |
|---|---|---|---|
| 83 | 2749 | 2.16 | -1.60 |
| 85 | 9461 | 1.99 | -1.53 |
| 90 | 9462 | 1.96 | -1.14 |
| 95 | 9463 | 1.97 | -1.26 |
| 100 | 9464 | 2.08 | -1.34 |
| 105 | 9468 | 2.13 | -1.47 |
| 110 | 9469 | 2.40 | -1.33 |
| 115 | 9470 | 2.58 | -1.28 |
| 120 | 9471 | 2.73 | -1.05 |
| 121 | 13855 | 2.71 | -1.01 |
| 122 | 13856 | 2.65 | -0.96 |
| 123 | 13857 | 2.66 | -0.90 |
| 124 | 13858 | 2.72 | -0.88 |
| 125 | 9472 | 2.67 | -0.92 |
| 126 | 13859 | 2.95 | -0.81 |
| 129 | 13869 | 2.88 | -0.85 |
| 130 | 9473 | 2.78 | -1.04 |
| 132 | 11713 | 2.71 | -0.98 |
| 135 | 9474 | 2.71 | -0.93 |
| 140 | 9475 | 2.50 | -0.90 |
| 145 | 9476 | 2.40 | -0.99 |
| 150 | 9477 | 2.38 | -0.86 |
| 156 | 9478 | 2.37 | -0.91 |
| 160 | 9479 | 2.30 | -0.98 |
| 165 | 9480 | 2.20 | -1.02 |
| 168 | 11714 | 2.23 | -0.88 |
| 169 | 11715 | 2.34 | -0.81 |
| 170 | 9481 | 2.07 | -0.84 |
| 171 | 11716 | 2.10 | -0.73 |
| 172 | 11717 | 2.23 | -0.68 |
| 173 | 1304 | 2.58 | -0.92 |
| 174 | 15073 | 2.49 | -0.71 |
| 175 | 9482 | 2.18 | -0.80 |
| 176 | 15074 | 2.74 | -0.37 |
| 178 | 15075 | 2.61 | -0.82 |
| 179 | 11718 | 2.79 | -0.68 |
| 180 | 9483 | 2.36 | -0.85 |
| 181 | 11719 | 2.34 | -0.72 |
| 182 | 1305 | 2.45 | -0.64 |
| 183 | 1306 | 2.48 | -0.52 |
| 184 | 1307 | 2.42 | -0.50 |
| 186 | 9484 | 2.18 | -0.76 |
| 191 | 11720 | 2.35 | -1.00 |

| | | | |
|---|---|---|---|
| 193 | 15080 | 2.55 | -1.29 |
| 198 | 15083 | 2.49 | -1.16 |
| 201 | 11722 | 2.52 | -1.25 |
| 207 | 1021 | 2.57 | -1.53 |
| 209 | 1022 | 2.68 | -1.57 |
| 213 | 1023 | 2.59 | -1.40 |
| 215 | 1024 | 2.71 | -1.29 |
| 219 | 1026 | 2.74 | -1.00 |